MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

Vol. XL SEPTEMBER-OCTOBER, 1948 No. 5

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PUBLISHED BIMONTHLY FOR
THE NEW YORK BOTANICAL GARDEN
AT PRINCE AND LEMON STS., LANCASTER, PA.

Entered as second-class matter April 30, 1925, at the post office at Lancaster, Pa., under the Act of August 24, 1912.

MYCOLOGIA

Published by

THE NEW YORK BOTANICAL GARDEN

IN COLLABORATION WITH THE

MYCOLOGICAL SOCIETY OF AMERICA

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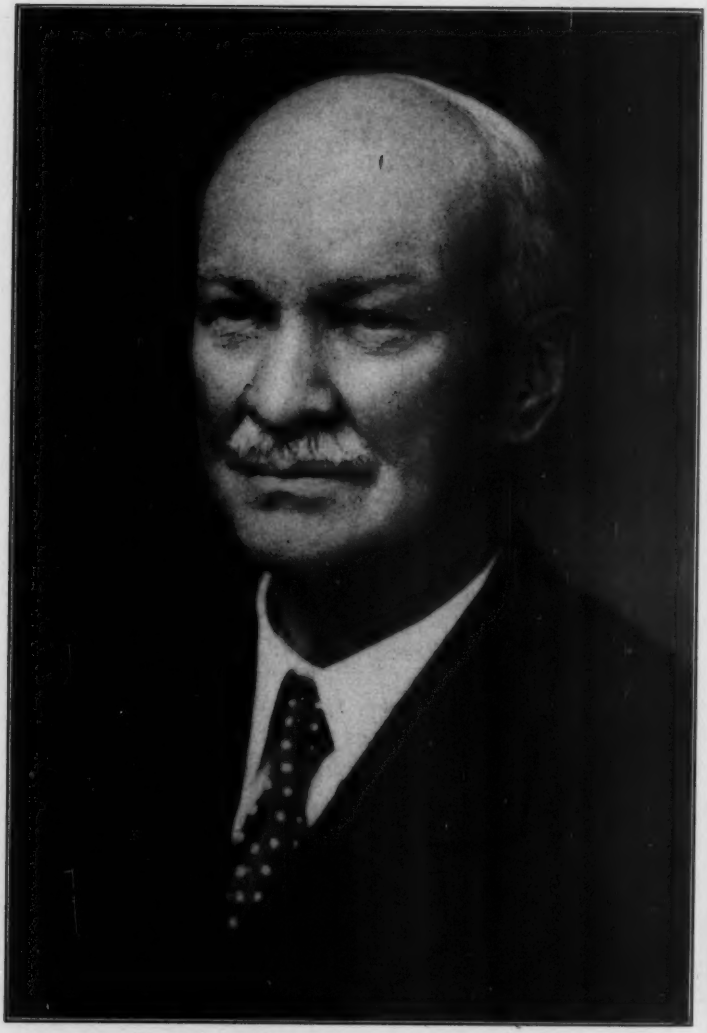

HENRY CURTIS BEARDSLEE

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HENRY CURTIS BEARDSLEE

GERTRUDE S. BURLINGHAM

Mr. Henry Curtis Beardslee, one of the leading mycologists in the United States, died at the age of eighty-two on January 1st, 1948, in Painesville, Ohio, the place of his birth. His interest in Nature and Botany began with the teaching of his father, a physician and botanist, who went with a group of Connecticut colonists to settle in the Western Reserve in Ohio. The Beardslees were of English and Scottish descent.

After graduation from the Painesville High School in 1883, Mr. Beardslee attended Oberlin College for one year before entering Adelbert College of Western Reserve University in Cleveland, Ohio, from which he was graduated with the degree of A.B. In 1892 he received the A.M. degree. Upon graduation he entered the teaching profession, teaching one year in the Academy at Green Springs, Ohio, following which he became teacher of Science in the University School in Cleveland, Ohio, where he remained eleven years.

In 1893 Mr. Beardslee was married to Miss Anna A. Ford, a graduate of Oberlin College. Mrs. Beardslee was much interested in his mycological work and in his teaching. After her death in November 1946, he wrote "I had fifty years of wonderful companionship and could not have been happier."

In 1901 with two associates he established the Asheville School for Boys where he remained as Senior Master until his retirement in 1919. During this time he gave intensive study to the fungous flora of the vicinity and in 1918 he published in the Journal of the Elisha Mitchell Scientific Society a Monograph on "The Rus-

[MYCOLOGIA for July–August (40: 391–504) was issued July 29, 1948]

sulas of North Carolina" illustrated by forty-one photographs of natural size, twenty-three of which were taken by himself, and the remainder by Prof. W. C. Coker of the University of North Carolina. Among the species were three described for the first time, *Russula cinerascens, R. pungens* and *R. magna,* also *R. rubescens* which had been previously described by him in Mycologia **6**: 91. '14. On the plate of spore drawings of twenty-eight species he brought out the patterns of reticulations which had not been shown in spore drawings. These drawings were made without the Crawshay iodine method which was published by Crawshay in "Spore Ornamentation of the Russulas" in 1930.

Mr. Beardslee was a very careful scientist, always obtaining the taste of the species of *Russula* in the field, and looking for any color changes in the flesh, and for any odor either in the fresh state or as it might develop later. The same care was given to collections of species in other genera. He spent one summer in Germany and at another time traveled over Europe during which time he met leading mycologists. In Sweden he had the privilege of collecting with Lars Romell, and with him going over the collecting grounds so familiar to Elias Fries.

After his retirement in 1919 he spent the winters in Florida, first on the East Coast, then in Central Florida at Longwood and Altamonte Springs. During this time he made extensive collections in many genera of fleshy fungi, accompanying the species with full notes, photographs and spore prints. Before his death he presented his herbarium to Oberlin College. Each year after the season for fleshy fungi was over he began to enlarge his herbarium of flowering plants.

In Mycologia **32**: 575–586. 1940 he cooperated with the writer in publication of seven new species of *Lactaria.*

Mr. Beardslee was a member of the American Association for the Advancement of Science, the Botanical Society of America, the Torrey Botanical Club, The Mycological Society of America, The British Mycological Society, and Phi Beta Kappa.

Not only did Mr. Beardslee make a lasting contribution to Mycology, but his influence as a scholar and a Christian gentleman will be passed on through the character of the men whom as boys he taught in the Asheville School in Asheville, North Carolina.

NEW SPECIES OF PENICILLIUM

KENNETH B. RAPER[1] AND DOROTHY I. FENNELL[2]

(WITH 11 FIGURES)

Through the cooperative effort of the United States Department of Agriculture and the National Science Fund, a comprehensive study of the genus *Penicillium* has been conducted at the Northern Regional Research Laboratory, during the past three years, leading to the preparation of a manual covering this important genus of molds (Raper and Thom, in press). An enormous number of *Penicillia* were examined culturally and microscopically, and in the course of this work eleven species and one variety which are believed to be new have been encountered. Both ascosporic and non-ascosporic forms are represented.

Cultures of species types are being deposited with the American Type Culture Collection, Washington, D. C.; the Centraalbureau voor Schimmelcultures, Baarn, Holland; and the collection maintained at The London School of Hygiene and Tropical Medicine.

All of the species currently described have been under observation for a period of at least one year, and some for more than five years. They have been grown upon a wide variety of culture media including Czapek's solution agar and various modifications of the same, malt extract, Sabouraud's dextrose, corn meal, and hay infusion agars. All of the forms grow well at room temperatures of 23 to 25° C. Since the development of diagnostic characteristics in certain of these new species seems to be dependent upon the use of particular substrata, the compositions of the media employed in this study are given.

[1] Principal Microbiologist, Fermentation Division, Northern Regional Research Laboratory, Peoria, Illinois. One of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, United States Department of Agriculture.

[2] Assistant Microbiologist, National Science Fund, and Cooperative Agent, Northern Regional Research Laboratory.

(1) *Czapek's solution agar:* Distilled water, 1 liter; sucrose, 30 gms.; $NaNO_3$, 3.0 gms.; K_2HPO_4, 1.0 gm.; KCl, 0.5 gm.; $MgSO_4 \cdot 7H_2O$, 0.5 gm.; $FeSO_4 \cdot 7H_2O$, 0.01 gm.; agar, 15 gms. The reaction is near neutral and is not adjusted.

(2) *Steep agar:* Czapek's solution agar plus the addition of 10 ml. concentrated corn steep liquor (ca. 50 per cent solids). The reaction is adjusted to pH 7.0 with NaOH before sterilization.

(3) *Malt extract agar:* Distilled water, 1 liter; malt extract (Difco), 20 gms.; dextrose, 20 gms.; peptone, 1.0 gm.; agar, 25 gms. The pH is approximately 4.7 and is not adjusted.

(4) *Corn meal agar:* Boil 50 gms. white corn meal (contained in cloth bag) in one liter distilled water for one-half hour, filter, and make up to original volume; add 15 gms. agar and sterilize. The reaction is approximately pH 8.0 and is not adjusted.

(5) *Hay infusion agar:* Cook 50 gms. decomposing hay in one liter of distilled water in autoclave for 30 minutes, filter. Add 2 gms. K_2HPO_4 and 15 gms. agar per liter of infusion filtrate, adjust reaction to pH 6.2 with HCl and sterilize.

(6) *20 per cent sucrose Czapek:* Similar to (1) above except containing 20 per cent rather than 3 per cent sucrose. The reaction is near neutral and is not adjusted.

(7) *Ammonium sulfate Czapek:* Similar to (1) above except containing 2.33 gms. $(NH_4)_2SO_4$ rather than 3.0 gms. $NaNO_3$. The reaction is approximately pH 6.8 and is not adjusted.

(8) *Sabouraud's dextrose agar:* Distilled water, 1 liter; peptone, 10 gms.; dextrose, 40 gms.; agar, 20 gms. The reaction is pH 5.6 to 5.7 and is not adjusted.

ASCOSPORIC SPECIES

Penicillium parvum sp. nov.

Coloniae in agaris omnibus valde restrictae; e coacta densa compositae vel pertenues, mycelio vegeto plurimum submerso, primum albae, demum sordide flavae usque pallide brunneae vel vinaceae; reverso vinaceo usque brunneo-rubro, fructificationibus conidicis sparsis; conidiophoris brevibus, vulgo 25–40 × 1.5 μ, glabris; penicillis parvis, constanter monoverticillatis; sterigmatibus in 3–6 verticillis parallelibus, 7.0–8.0 × 1.2–1.5 μ; conidiis primum ellipticis, 1.5–2.0 × 1.2–1.5 μ, in aetate subglobosis, breve catenatis; peritheciis sphaericalibus vel oblongis, plerumque 100 μ in diam. non excedentibus, non-ostiolatis, alutaceis usque pallide brunneis, primum sclerotioideis, a centro extus tarde maturescentibus, peridio integro cellulas duas vel tres crasso; ascis globosis vel ovalibus, 6.0–7.0 μ in diam., octosporis; ascosporis lenticularibus, parvissimis, 2.0–2.4 × 1.5–1.8 μ, distincte asperatis et costis prominentibus equatorialibus praeditis.

In culturis e solo, Nicaragua.

Colonies on Czapek's solution agar growing very restrictedly, attaining a diameter of 1.5 to 2.0 cm. in two weeks and 3 to 4 cm. in four to five weeks, raised 1 to 2 mm., sometimes folded or wrinkled

(FIG. 1*A*), consisting of a very tough close-textured mycelial felt with surface characterized by a thin growth of fine aerial hyphae appearing somewhat floccose, mostly in white through flesh to dull yellow shades, becoming deeper and somewhat vinaceous (Ridgway, Pls. XXVII and XL) in age, penicilli usually lacking (see hay agar); incipient perithecia developing within two to three weeks, spherical to oblong or slightly angular, yellow in color, buried deep

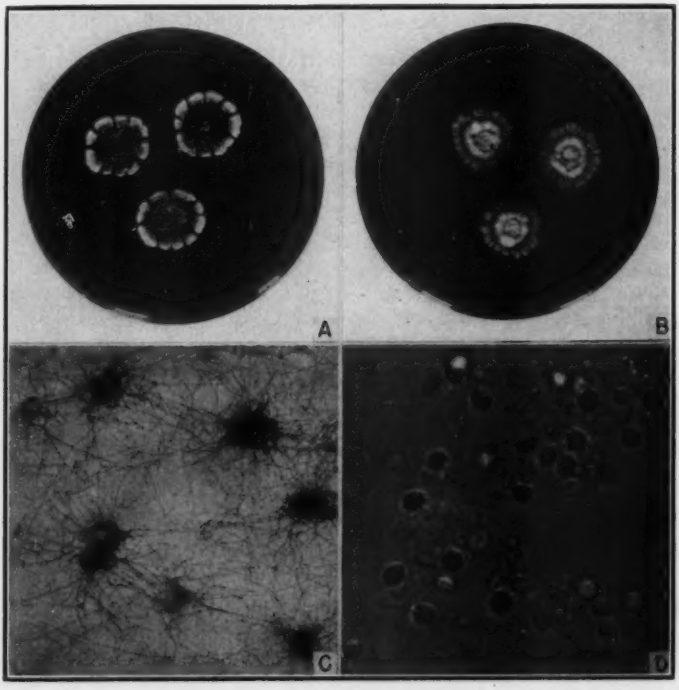

FIG. 1. *Penicillium parvum.*

in the mycelial felt, failing to produce asci and ascospores even within four to five weeks; exudate usually abundant, in rich brown shades becoming deep purple-brown in age; odor lacking or indistinct; reverse at first in vinaceous fawn shades becoming deep maroon in age.

Colonies on steep agar restricted but growing more rapidly than above, 2.0 to 2.5 cm. in two weeks, in texture and appearance essentially as on Czapek but with surface of looser texture and

deeper; exudate more abundant, deep maroon; penicilli usually lacking; not developing asci and ascospores within one month.

Colonies on malt agar about 1.5 to 2.0 cm. in two weeks, 0.5 to 1.0 mm. deep, plane or nearly so, consisting of a dense layer of perithecia adjacent to the agar surface, commonly overgrown by a thin, loose network of orange to light brown aerial hyphae, lending to the colony its characteristic texture and color; penicilli very few in number, strictly monoverticillate, on short branches from submerged or trailing hyphae, not affecting the colony appearance; no exudate or odor; reverse in dull brown shades.

Colonies on hay infusion agar restricted, about 2.5 to 3.0 cm. in three to four weeks, very thin, vegetative mycelium largely submerged, producing numerous perithecia in an uneven layer at the agar surface to give a granular effect (FIG. 1*B*), in tan to brown shades; penicilli very few in number, developing primarily at the colony margins in old plates, strictly monoverticillate, borne on short branches from submerged or trailing hyphae; conidiophores short, usually 50 μ or less and commonly 25 to 40 μ in length by about 1.5 μ in diameter, smooth-walled; penicilli consisting of verticils of 3 to 6 parallel sterigmata; sterigmata mostly 7 or 8 μ by 1.2 to 1.5 μ with conidium-bearing tips slightly narrowed; conidia at first definitely elliptical, about 1.5 to 2.0 μ by 1.2 to 1.5 μ, in age becoming almost subglobose, mostly 1.5 to 1.8 μ in diameter, smooth-walled, adhering in fairly long chains in fluid mounts. Perithecia spherical to oblong (FIG. 1*C*), mostly 100 μ or less in diameter, occasionally up to 150 μ, surrounded by very thin wefts of sterile hyphae, at first tending to be sclerotioid and of uniform texture throughout, consisting of heavy-walled pseudoparenchyma, ripening late and from the center outward, beginning to develop asci and ascospores in three to four weeks, at two months filling the perithecium except for an outer wall 2 to 3 cells thick; asci apparently borne as lateral branches from fertile hyphae, chains not seen, round to oval in outline, about 6 to 7 μ at maturity, 8-spored; ascospores lenticular, very small, 2.0 to 2.4 μ by 1.5 to 1.8 μ, with walls definitely roughened and with two prominent equatorial ridges rather widely separated to give a definite pulley-like appearance (FIG. 1*D*).

Colonies on corn meal agar spreading slowly, 5 to 6 cm. in four weeks, very thin, vegetative mycelium submerged; perithecia produced abundantly along radiating dendroid lines, surrounded by very sparse hyphal networks, developing and ripening as on hay agar; penicilli usually absent.

Species description based upon NRRL *2095* as **type**, isolated in July 1945 from a sample of soil from Nicaragua contributed by Dr. A. G. Kevorkian.

The binomial, *Penicillium parvum*, was selected because of the minute character of the penicilli, conidia, and ascospores. *Penicillium minutum* would have constituted a more suitable name, but the describers refrained from adopting this because of Bainier and Sartory's (**1913**) use of the name *Citromyces minutus* for an apparently strictly conidial form.

Penicillium parvum is believed to be more nearly related to *P. javanicum* van Beyma (**1929**) than to any other described species. It resembles the latter in producing colonies marked by a rich reddish brown pigmentation in reverse; in showing strictly monoverticillate penicilli borne on short branches; and in developing perithecia—at first sclerotioid in character—which subsequently ripen from the center outward. It differs from this species in its more restricted growth upon all media, particularly upon Czapek's solution agar; in the smaller dimensions of conidial structures and parts of the same; in the more delayed ripening of its perithecia and, particularly, in the character of its ascospores. These are consistently smaller, more conspicuously roughened and show more strongly developed equatorial ridges and furrows. The species is represented, at present, by a single strain.

Penicillium parvum is apparently favored by a culture substrate of high osmotic tension. It grows better upon all substrata as these dry out in the culture plate or tube, producing conidial structures on most media only in marginal areas of aging cultures. The production of penicilli upon agar media to which a high concentration of NaCl has been added affords additional evidence. Growth of the fungus upon Czapek's solution agar is increased when the sugar concentration is raised to 20 per cent.

Penicillium levitum sp. nov.

Coloniae in agaro Czapekii satis restrictae et coacta dense texta, valde rugosa efficientes, in agaro maltoso effusae, tenues planaeque, primum albae, plerumque vetustae bubalinae vel alutaceae; reverso flavo; fructificatione conidica sparsa; conidiophoris plerumque ex hyphis aereis, 20–50 × 2.0–2.8 μ, glabris; penicillis monoverticillatis, parvis; sterigmatibus saepe in 3–5 verticillis simplicibus, interdum geminatis vel singulis, plerumque 7.0–12.0 × 2.2–3.3 μ; conidiis globosis vel ovalibus, 3.0–8.0 μ in diam., plerumque 4.0–6.0 μ, glabris, breve catenatis; peritheciis in agaro maltoso et milii indici abundantibus, globosis vel subglobosis, usque 100 μ diam., pallide alutaceis, primum pseudoparenchymatibus, ascis et ascosporis aream centralem implentibus,

peridio cellulari, cellulas 1–2 crasso; ascis singulis, ovalibus vel oblongis, 8–10 μ in diam., octosporis; ascosporis late ellipticis vel subglobosis, 3.5–4.5 × 3.0–4.0 μ, glabris, costis rimisque aequatorialibus carentibus.

In culturis ex argilla, New York.

Colonies on Czapek's solution agar growing rather restrictedly, about 3.0 to 4.0 cm. in two to three weeks at room temperature, comparatively thin, consisting of a close felt tearing with difficulty, central area raised, often pulling away from the culture dish and usually splitting along deep radial furrows (FIG. 2*A*), surface appearing almost velvety but consisting of a thin network of short, closely interwoven vegetative hyphae, white but gradually developing light buff to flesh shades in marginal areas, in age sometimes showing yellow and lilac zones, conidia limited, borne on very reduced fruiting structures (see 20 per cent sucrose Czapek agar) commonly consisting of single sterigmatic cells, not influencing the colony appearance; perithecial primordia present in limited numbers (see malt agar), buried in the mycelial felt, not developing mature asci or ascospores and not affecting the colony appearance; exudate limited, clear; odor lacking; reverse in yellow shades from citrine to dull buff.

Colonies on Czapek's solution agar containing 20 per cent sucrose as described above but developing conidial structures and perithecial initials more abundantly; conidiophores arising as short branches from aerial hyphae, smooth-walled, mostly 20 to 35 μ by 2.0 to 2.8 μ, often shorter and rarely longer than 50 or 60 μ; penicilli consistently small, simple (FIG. 2*C*); sterigmata rarely more than 4 or 5 in the verticil, commonly irregularly arranged, often occurring in pairs or singly, variable in size, mostly 7 to 12 μ by 2.2 to 3.3 μ when borne in clusters, up to 20 to 25 μ by 3.0 to 3.5 μ when arising singly, showing some tendency to be wedge-shaped but narrowing to conidium bearing tubes; conidia globose to subglobose, oval or somewhat pyriform with comparatively heavy, smooth walls, varying greatly in dimensions (FIG. 2*C*), mostly 4.0 to 6.0 μ in diameter but ranging from 3.0 to 8.0 μ, borne in very short divergent chains, consistently larger in some chains than in others.

Colonies on steep agar growing as on Czapek but less deeply furrowed, producing abundant perithecia (largely near the colony surface) which ripen within 10 days to 2 weeks.

Colonies on malt agar spreading broadly, attaining a diameter of 6 cm. in two to three weeks, plane, occasionally zonate, growing margin 0.5 to 1.0 cm. wide, white to light flesh colored, central area in shades near avellaneous from the abundant perithecia borne in a loose mycelial felt; conidial structures lacking or very limited in

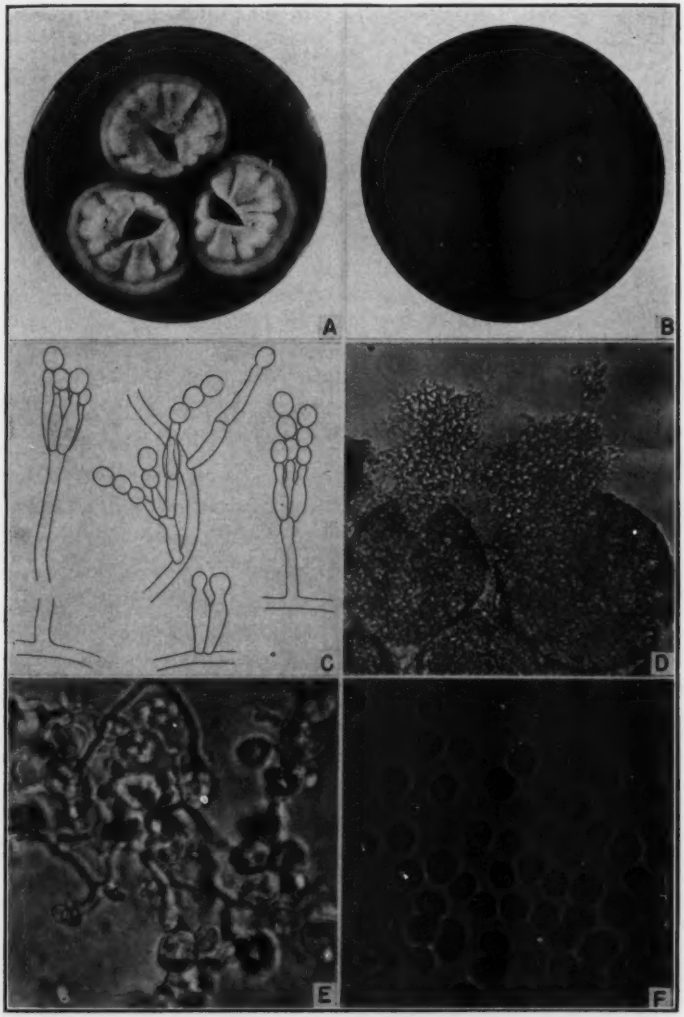

FIG. 2. *Penicillium levitum.*

number; perithecia spherical or nearly so, mostly 50 to 100 μ in diameter, in light tan shades, at first consisting of pseudoparenchyma throughout but quickly developing fertile tissue in central areas; asci evident within 4 to 5 days and ascospores beginning to ripen within a week, fertile area progressing outward and within 10 days to 2 weeks filling the entire perithecium except for a thin peridium (FIG. 2*D*) one to two cells thick; asci borne as short branches from fertile hyphae (FIG. 2*E*), not in chains, spherical to oval or oblong, 8 to 10 μ in diameter when mature, 8-spored; ascospores smooth, polished, broadly elliptical to subglobose, 3.5 to 4.5 μ by 3.0 to 4.0 μ, comparatively heavy-walled, without any indication of equatorial furrow or ridges (FIG. 2*F*).

Colonies on corn meal agar spreading broadly, up to 6 cm. in two to three weeks (FIG. 2*B*), very thin, vegetative mycelium submerged or forming a loose network at the agar surface; perithecia rather sparsely produced, with form, dimensions, and development as on malt agar; conidial stage lacking or very limited.

Species description based upon NRRL *705* as **type**, received without name from Dr. B. O. Dodge in 1936 as an isolate from modeling clay. This culture has been maintained in our collection since that date as an unidentified member of the general series with *Penicillium brefeldianum* Dodge (**1933**). Careful examination of this culture during our current study and detailed comparison with described species lead us to regard the form as new. The binomial, *P. levitum*, from the Latin *lēvitas* (smoothness), is applied because of the conspicuously smooth character of all walls, especially those of conidia and ascospores.

Upon most substrata, and particularly those containing vegetable extracts, the stock strain of *Penicillium levitum* produces abundant perithecia but very few sterigmatic cells, either grouped as simple penicilli or arising singly from aerial hyphae. Sector variants characterized by increased conidium formation and an absence of perithecia are occasionally observed, and sub-cultures derived from these seem to maintain the characteristics of the sectors. Conidia are produced fairly abundantly and upon some substrata, *e.g.*, 20 per cent sucrose Czapek, the colony surface may assume a light, pale blue-gray tint. While the number of conidia produced in such variant sub-strains is much greater than in the stock, the penicilli produced are not more complex and seldom show clusters of more than

4 or 5 sterigmata. Measurements of conidia and sterigmatic cells remain unchanged.

The perithecia of *Penicillium levitum* are less highly specialized than the initially sclerotioid structures which characterize such monoverticillate species as *P. javanicum* v. Beyma and *P. ehrlichii* Klebahn (**1930**). Conidial structures also differ from other members of the series. Whereas 4 or 5 sterigmata may be arranged in a simple verticil, meeting the essential requirement for placement in the genus *Penicillium,* such definite structures are not consistently produced and the total conidial picture is strongly suggestive of the genus *Monascus.* Such relationship is further suggested by the fact that ascus walls break down rather quickly, leaving the spores free within the ripening perithecium. The species is regarded as properly assignable in the genus *Penicillium,* but somewhat transitional in the direction of *Monascus.*

Perithecia of *Penicillium levitum* ripen more rapidly but apparently follow the same basic pattern of development shown by *P. javanicum* v. Beyma. The young perithecium rapidly assumes its ultimate size and appears pseudoparenchymatous throughout. A mass of fertile tissue soon develops in the central area and, in contrast to two or more weeks in such species as *P. javanicum* and *P. parvum,* asci may appear as early as the 4th or 5th day. The mass of asci and ascospores usually fills the perithecium within two weeks or less and a thin peridium one or two cells thick confines the ascospores at maturity. The perithecium is hardly firm at any stage and is certainly not sclerotioid, but the continuity of the pseudoparenchymatous tissue when young and the presence of a definite continous wall at maturity seem to relate it unquestionably to *P. brefeldianum* Dodge and *P. javanicum* v. Beyma.

Penicillium helicum sp. nov.

Coloniae in agaro Czapekii multo restrictae, comparative tenues, laxe textae, fructificationes conidicas paucas et perithecia rara gerentes; in agaro maltoso late crescentes, peritheciis abundantibus, aureo-flavae, reverso aurantio-rubro; conidiophoris 75–100 × 2.0–2.5 μ, glabris vel irregulariter asperatis; penicillis typice biverticillatis et symmetricis, sed saepe non ab omni parte vel monoverticillatis; metulis in 3–4 verticillis 10–15 × 2 μ; sterigmatibus lanceolatis, apicibus acuminatis, in 6–7 verticillis 8.0–12.0 × 2.0–2.5 μ; conidiis ellipticis, 3.0–3.5 × 2.5 μ, glabris; peritheciis laxe textis, mollibus, ex hyphis intertextis intense coloratis limitatis, circa 200–250 μ in diam., saepe conflu-

entibus; ascis catenatis, sphaericalibus usque ovatis, 5.5–7.0 μ, octosporis; ascosporis ellipticis superficiem totam spinulosis, 2.5–3.0 × 1.4–1.8 μ.

In culturis e solo, Suecia.

Colonies on Czapek's solution agar growing restrictedly, commonly not exceeding 1.5 to 2.0 cm. in two to three weeks at room temperature, comparatively thin, with vegetative mycelium largely submerged and with surface growth comparatively loose, almost

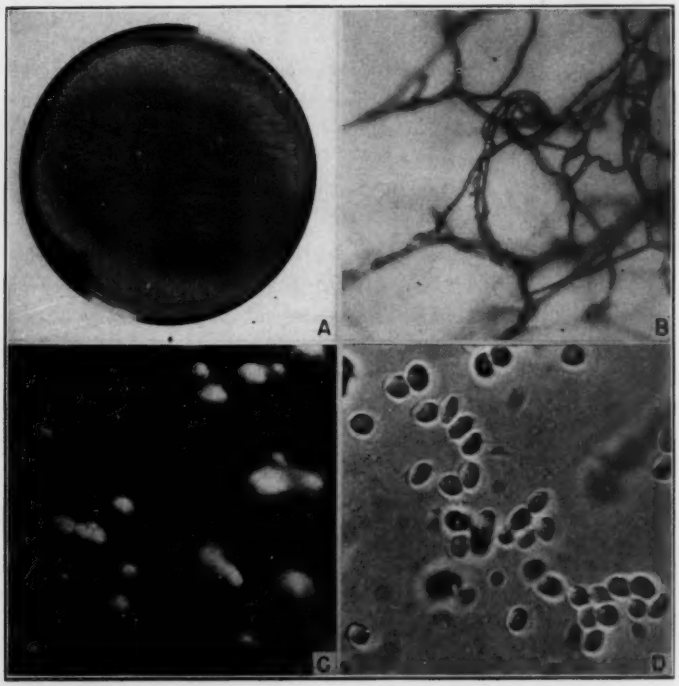

FIG. 3. *Penicillium helicum.*

floccose, in flesh to orange-pink shades, tardily developing conidial structures in limited numbers; rarely producing perithecia (see malt agar); odor not pronounced; exudate limited or lacking; reverse at first colorless, developing red shades in age; penicilli variable in pattern, mostly fractional, commonly appearing monoverticillate, sometimes branched and asymmetric, sometimes biverticillately symmetrical in the manner characteristic of the Biverticil-

lata-Symmetrica section to which the species is assigned (*cf.* FIG. 11*C*); conidiophores borne primarily as branches from aerial hyphae; commonly 100 μ or less in length by 2.0 to 2.5 μ, with walls smooth or irregularly roughened and colored in light yellow-green shades; metulae variable, when present commonly 10 to 15 μ by about 2.0 μ, rarely occurring in clusters of more than 3 or 4; sterigmata tapered in the manner characteristic of the section, produced in limited clusters up to 6 or 7, variable in dimensions, 8 to 12 μ by 2.0 to 2.5 μ, bearing conidia in divergent chains; conidia elliptical, smooth, about 3.0 to 3.5 μ by 2.5 μ.

Colonies on malt extract agar spreading broadly, up to 6 to 7 cm. in twelve to fourteen days, plane (FIG. 3*A*), comparatively thin, consisting of a loose network of aerial mycelium in which abundant perithecia soon develop with accompanying encrusted and pigmented hyphae to give the colony a rich golden yellow color, in age near light cadmium to aniline yellow (Ridgway, Pl. IV); conidial structures lacking or limited in number, odor lacking; no exudate; reverse in brownish orange shades; perithecia generally spherical or nearly so (FIG. 3*C*), ranging from 100 to 300 μ in diameter, usually about 200 to 250 μ, soft, loose-textured, sometimes confluent, without specialized cellular walls but bounded by thin networks of interwoven hyphae, and surrounded by loose coverings of twisted or spiral, encrusted and pigmented hyphae up to 150 to 200 μ or more in length; asci produced abundantly throughout, borne in short chains, at maturity spherical to ovate, 5.5 to 7.0 μ in diameter, 8-spored, walls of asci breaking down quickly to leave the perithecial cavity filled with free ascospores; ascospores very small, elliptical (FIG. 3*D*), about 2.5 to 3.0 μ by 1.4 to 1.8 μ, delicately spinulose over the entire surface.

Colonies on corn meal agar spreading fairly broadly, 5 to 6 cm. in two weeks, vegetative mycelium largely submerged and producing scattered perithecia and limited conidial structures, mostly fractional.

Perithecial initials (FIG. 3*B*) readily observed upon most substrata, particularly upon corn meal agar. These first appear as thickened, clubshaped hyphae (ascogonia?) around the base of which coil much thinner hyphae (antheridia?). The latter type of hypha confines itself to the basal area of the club-shaped structure and usually terminates as a slight enlargement closely appressed against the wall of the larger hypha. The club-shaped hypha apparently elongates and soon begins to coil terminally, at first in a loose helix-like pattern and subsequently as a rather tight spiral. As the spiral continues to develop, its identity is soon lost in a developing knot of interwoven tissue. We have not succeeded in establishing whether this knot develops primarily by the septation

and repeated branching of the coiled structure or by the proliferation of adjacent hyphae. The developmental history of the perithecium has not been elucidated, but the origin and pattern of ascus formation can be fairly well worked out in the ripening perithecium.

Species description based upon NRRL *2106* as **type**, isolated from soil sent to us in 1945 from Sweden by Professor Edy Velander.

Penicillium helicum is distinguished from other members of the ascosporic *P. luteum* series by the coiled helix-like pattern of its perithecial initials and the small dimensions of its ascospores. When young the perithecial initials are strongly suggestive of *P. vermiculatum* Dangeard (**1907**), but as these develop they assume a markedly different and specific pattern.

The name, *Penicillium helicum*, is based upon the characteristically coiled structures that distinguish the species, and is taken from the Latin *helica*, meaning winding.

Penicillium rotundum sp. nov.

Coloniae in agaris omnibus restrictae, satis compactae, primum plurimum mycelicae sed mox perithecia abundantia gerentes, aureo-flavae, reverso aurantio vel rubro; fructificatione conidica sparsa; conidiophoris e substrato orientibus, usque 200 × 3.0 μ; penicillis typice biverticillatis et symmetricis, sed saepe non ab omni parte; metulis in verticillis 4 vel paucioribus, 10–13 × 2.0–2.5 μ; sterigmatibus lanceolatis, apicibus acuminatis, strictim parallelibus, in 4–7 verticillis, circa 10–12 × 1.5–2.0 μ; conidiis ellipticis, 2.5–3.0 × 2.0–2.5 μ glabris; peritheciis globosis vel subglobosis, 150–300 μ in diam., laxe textis, mollibus, rete hypharum intertextarum limitatis, interdum confluentibus, cito maturescentibus; ascis catenatis, ovatis vel globosis, 12.5–15.0 μ in diam., octosporis; ascosporis globosis, crasse tunicatis, superficiem totam echinulatis, 4.5–5.0 μ in diam.

In culturis e ligno, Panama.

Colonies on Czapek's solution agar growing very restrictedly, about 1.0 cm. in two weeks at room temperature, consisting of a compact, fairly tough felt up to 500 μ or more deep, at first largely mycelial but developing abundant inconspicuous perithecia (see malt agar) after one week to ten days and showing bright golden yellow shades from pigmentation of the perithecia and the encrusted hyphae surrounding them; penicilli generally lacking or, if present, limited in number and usually fragmentary (see 20 per cent sucrose Czapek), not affecting the colony appearance; exudate limited, light amber in color; odor slight or lacking; re-

verse in yellow to orange-red shades with surrounding agar lightly colored.

Colonies on Czapek's solution agar with 20 per cent sucrose growing restrictedly as above, plane, producing abundant conidial structures in a dense stand, velvety or nearly so, in pale gray-green shades near olive gray (Ridgway, Pl. LI) to storm gray (R., Pl. LII), conidiophores arising primarily from the substratum, com-

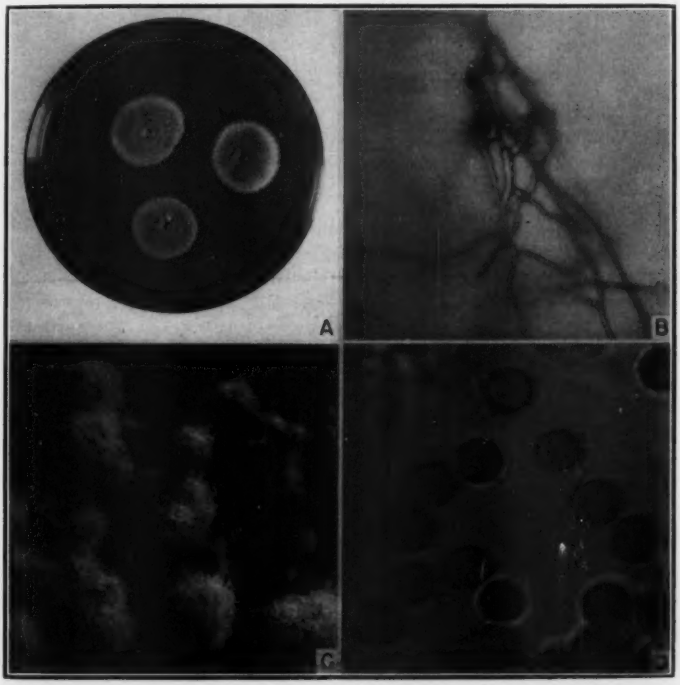

FIG. 4. *Penicillium rotundum.*

paratively short, seldom exceeding 200 μ in length by 3.0 μ in diameter; penicilli variable, ranging from fractional or monoverticillate to typically biverticillate and symmetrical (*cf.* FIG. 11*C*); metulae in limited verticils, rarely exceeding 4 in number, 10 to 13 μ by 2.0 to 2.5 μ; sterigmata closely parallel, in clusters of 4 to 6 or 7, about 10 to 12 μ by 1.5 to 2.0 μ, with conidium-bearing tips definitely tapered in the manner characteristic of the Biverticillata-Symmetrica section to which the species unmistakably belongs; conidia

elliptical, with ends more or less pointed, mostly 2.5 to 3.0 μ by 2.0 to 2.5 μ, smooth-walled.

Colonies on malt extract agar growing slowly (FIG. 4*A*), 1.5 to 2.0 cm. in two weeks, in bright golden yellow shades near lemon-chrome to light cadmium (Ridgway, Pl. IV), with growing margin 1 to 2 mm. wide, thin, often largely submerged, quickly developing abundant perithecia to form a continuous layer which in the main constitutes the colony, becoming rich golden orange near deep chrome to cadmium yellow (R., Pl. III) after two weeks; perithecia usually globose or nearly so but varying greatly in size from 150 to 300 or 350 μ in diameter, sometimes confluent, without definite cellular walls, bounded by a thin network of interwoven hyphae (FIG. 4*C*) and surrounded by a loose covering of predominantly radiate, heavily encrusted, and strongly pigmented hyphae, 100 μ or more in length; perithecia ripening within 7 to 10 days, producing abundant asci throughout; asci borne in short chains, ovate to globose when mature, 12.5 to 15.0 μ in diameter, 8-spored; ascospores globose (FIG. 4*D*), definitely echinulate over the entire surface, mostly 4.5 to 5.0 μ in diameter, with walls heavy, 1.0 μ or more thick.

Colonies on corn meal agar slow-growing, about 2 cm. in 2 weeks, thin with mycelium largely submerged, producing perithecia abundantly at colony center and scattered throughout the entire colony area, in form and development as on malt; penicilli very limited in number.

Perithecial initials (FIG. 4*B*) readily observed at the margin of growing colonies upon most substrata, particularly corn meal and malt extract agars, irregular in origin and pattern (not consistent as in *Penicillium vermiculatum* Dangeard and *P. helicum*), first evident as swollen and irregularly septate hyphal elements which may be more or less twisted or coiled and which may arise either directly from vegetative hyphae, or from structures at first appearing penicillate, quickly developing into a knot of twisted and interwoven hyphal elements. Definite ascogonia are usually not identifiable.

Species description based upon NRRL *2107* as **type**, received in March 1946 from Professor G. W. Martin, University of Iowa, as an isolate from wood collected in the mountains of Chiriqui Province, Panama.

The species is distinguished by its restricted growth upon all substrata, the rich golden yellow color of its massed perithecia, the variability of its perithecial initials, and particularly by its large

globose ascospores. The specific name is based upon the shape of the ascospores.

The species is believed to be more closely related to *Penicillium wortmanni* Klöcker (**1909**) than to other members of the ascosporic *P. luteum* series. It differs from *P. wortmanni* principally in the character of its perithecial initials and its globose ascospores. In form, the latter are similar to the spores of *P. bacillosporum* Swift (**1932**) but are consistently larger. It is readily distinguished from the latter species by differences in habits of growth, coloration, and particularly conidial patterns—the conidia of Swift's species being strongly bacilliform as the name implies.

Penicillium striatum sp. nov.

Coloniae in agaro Czapekii restrictae sed in maltoso late crescentes, comparative tenues, penicillos paucos sed perithecia abundantia gerentes, albae usque pallide bubulinae, reverso rubro-brunneo vel purpurascenti; conidiophoris ex hyphis aereis orientibus, glabris; penicillis parvis, plerumque monoverticillatis, interdum biverticillatis sed asymmetricalis; metulis si praesentibus altitudinibus differentibus orientibus, 8.0–10.0 × 3.0–3.5 μ; sterigmatibus in quoque verticillo paucis, 8.0–10.0 × 2.5–3.0 μ, apicibus distincte attenuatis; conidiis mox deciduis, ellipticalibus, 3.0–4.0 × 2.5–3.0 μ, glabris; peritheciis laxe textis, byssoideis peridio indefinito, usque 150 μ diam.; ascis singulis, oblongis usque sphaericalibus, circa 15 μ diam.; ascosporis ellipticis, 7.0–8.5 × 5.0–6.0 μ, 8–10 taeniolis undulatis, latis, longitudinalibus, apices sporae versus convergentibus cinctis.

In culturis e fructo *Vaccinii* condito.

Colonies on Czapek's solution agar growing very restrictedly (FIG. 5*A*), attaining a diameter of 1.0 to 1.5 cm. in two weeks at room temperature, with margin uneven from the irregular and localized growth of the vegetative mycelium, growing deeply in the agar with aerial hyphae and later perithecia developing above this deep mycelial growth, white to pale buff in color, with surface mealy or granular, conidial structures very limited in number and not affecting the colony appearance, vegetative mycelium comparatively coarse with hyphal tips at colony margin often showing inflated cells; perithecia abundantly produced, developing throughout the entire area, loose-textured, cottony, without definite cellular walls (FIG. 5*D*), ranging up to 100 to 150 μ in diameter; exudate not produced; odor lacking or indefinite; reverse at first colorless becoming dull brown in age; penicilli very sparsely produced (see 20 per cent sucrose Czapek). Perithecia ripening rather quickly with asci containing immature spores within seven to eight

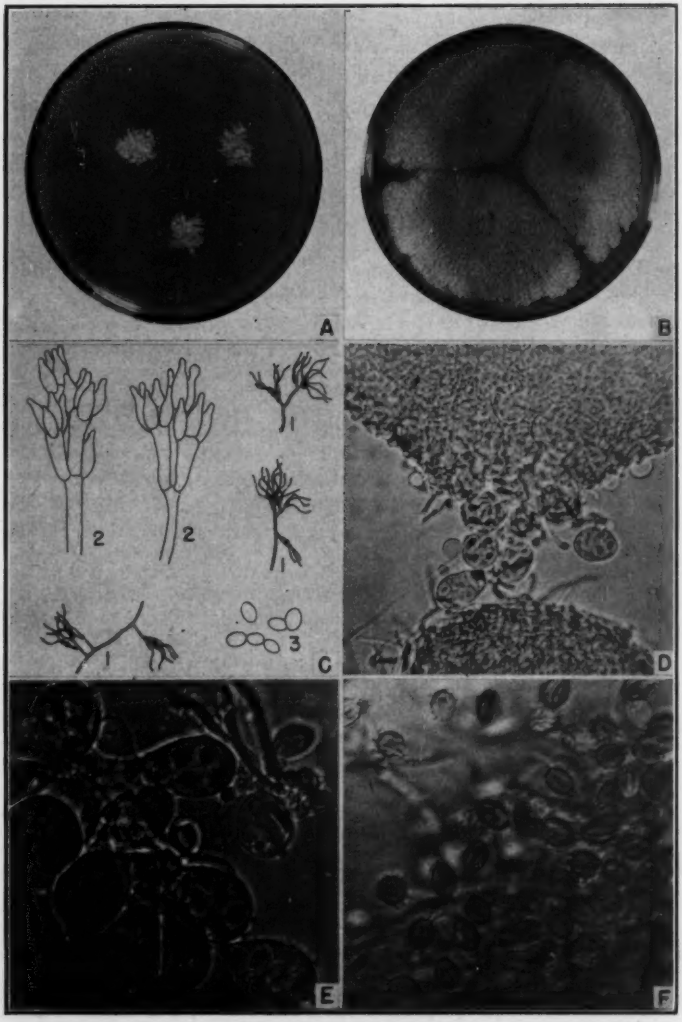

FIG. 5. *Penicillium striatum.*

days and with ripe ascospores present in twelve to fourteen days; asci apparently arising as branches from fertile hyphae, not in chains (FIG. 5*E*), oblong to spherical, about 15 μ in diameter, 8-spored; ascospores comparatively large, elliptical, with over-all dimensions ranging from 7.0 to 8.5 by 5.0 to 6.0 μ, with walls bearing a series of wavy, longitudinal flanges or frills (FIG. 5*F*), about 1.0 μ in width, usually extending the entire length of the spore, and tending to converge at the two ends.

Colonies on steep agar growing more rapidly, attaining a diameter of 3.5 to 4.5 cm. in two weeks at room temperature, with margins more regular than above, often entire, with surface appearing slightly granular from abundant perithecia or almost velvety where these become confluent, at first white, becoming buff to light brown in central areas in age; exudate very limited, clear; reverse in dull to reddish brown shades; penicilli very limited in number; perithecia very abundant, often forming a continuous layer; ascospore development and measurement as above.

Colonies on malt agar spreading broadly, attaining a diameter of 6.0 to 7.0 cm. in two weeks, thin, plane (FIG. 5*B*), conspicuously granular in appearance with perithecia in a dense layer at the agar surface and surrounded by thin loose networks of vegetative hyphae; reverse ranging from dull brown to purple; penicilli sparsely produced; perithecia ripening within ten days.

Colonies on 20 percent sucrose Czapek agar thin, restricted, producing penicilli more abundantly than on the above media; penicilli irregular in pattern and complexity (FIG. 5*C*), commonly monoverticillate but often developing as biverticillate structures without consistent arrangement of parts (FIG. 5C_2); conidiophores mostly short, 50 μ or less, borne as branches from aerial hyphae (FIG. 5C_1), occasionally arising from the substratum and 100 μ or more in length, smooth-walled, about 3.0 μ in diameter; penicilli simple, monoverticillate and consisting of a terminal verticil of 3 to 5 or 6 sterigmata, or biverticillate with 2 or more metulae or branches arising at a single or different levels (FIG. 5*C*), 8 to 10 μ or more in length by 3.0 to 3.5 μ in diameter, occasionally almost ramigenous and consisting of a number of short, divergent, irregularly arranged, branches bearing sterigmata; sterigmata variable in form and dimensions but mostly 8 to 10 μ by 2.5 to 3.0 μ with conidium-bearing tips short and definitely narrowed; conidia quickly deciduous, elliptical (FIG. 5C_3), mostly 3.0 to 4.0 μ by 2.5 to 3.0 μ, with ends usually somewhat pointed, walls smooth and comparatively heavy.

Species description centered upon NRRL *717*, as **type**, isolated in 1938 by Williams, Cameron, and Williams (**1941**) from canned

blueberries. A second strain, NRRL 2080, was isolated in January 1946 from a sample of soil sent to us from Sweden by Professor Edy Velander. This latter culture differs from the former only in producing colonies slightly more restricted and ascospores with flanges less consistently parallel. A third strain similar to the second was isolated from Swedish soil but was not retained.

The proper placement of *Penicillium striatum* remains in doubt. The general characteristics of its perithecia are somewhat suggestive of the genus *Gymnoascus*. Among the ascosporic *Penicillia*, they are most nearly approximated in *P. wortmanni* Klöcker, *P. luteum* Zukal (**1889**), and allied members of the *P. luteum* series. Saccardo (Sylloge XI, p. 437. 1895) went so far as to transfer Zukal's species to Baranetzky's genus *Gymnoascus*. The ascospores are unusually large, and show a unique type of ornamentation. Conidial structures vary in complexity from strictly monoverticillate, composed of terminal verticils of sterigmata numbering up to 5 or 6 or occasionally more, to variously branched and biverticillate, but never show either the characteristic symmetric pattern or the long tapered sterigmata that are characteristic of the Biverticillata-Symmetrica section. Despite the basic differences shown by its conidial stage, the species is tentatively placed in the *P. luteum* series with other species producing soft, loose-textured perithecia without walls composed of definitely specialized cells. More exact placement must await further examination of the developmental history of the fungus, or the isolation of additional strains transitional between it and other well defined species.

NON-ASCOSPORIC SPECIES

Sclerotigenic Species

Penicillium lapidosum sp. nov.

Coloniae expandentes, comparative tenues, planae vel subplanae, mycelio vegeto largiter submerso, sclerotiis mox crescentibus, abundantibus, primum aurantiacae demum aurantio-brunneae vel rubescentes, reverso concolori; fructificatione conidica sparsa; exsudato plerumque abundanti, aurantio-rubro; conidiophoris sparsis, ex hyphis repentibus orientibus, plerumque 25–75 × 2.5–3.5 μ; penicillis variabilibus, plurimum monoverticillatis sed interdum 1–2-ramosis; sterigmatibus in verticillis 7–8 compactis, 6.0–7.5 × circa 2.0 μ, apicibus attenuatis; conidiis ellipticis vel interdum subglobosis, 2.5–3.0 × 2.0–

2.5 μ, glabris, in catenis laxe parallelibus usque 100 μ longis; sclerotiis, globosis vel subglobosis, usque 300–350 μ in diam., perduris, lapidosis, e cellulis crasse tunicatis 10–15 μ in diam. compositis.

In culturis e fructo *Vaccinii* condito, Washington, D. C.

Colonies on Czapek's solution agar spreading broadly, attaining a diameter of 5.0 to 6.0 cm. within two weeks at room temperature, plane (FIG. 6*A*) or lightly furrowed, golden orange in color, de-

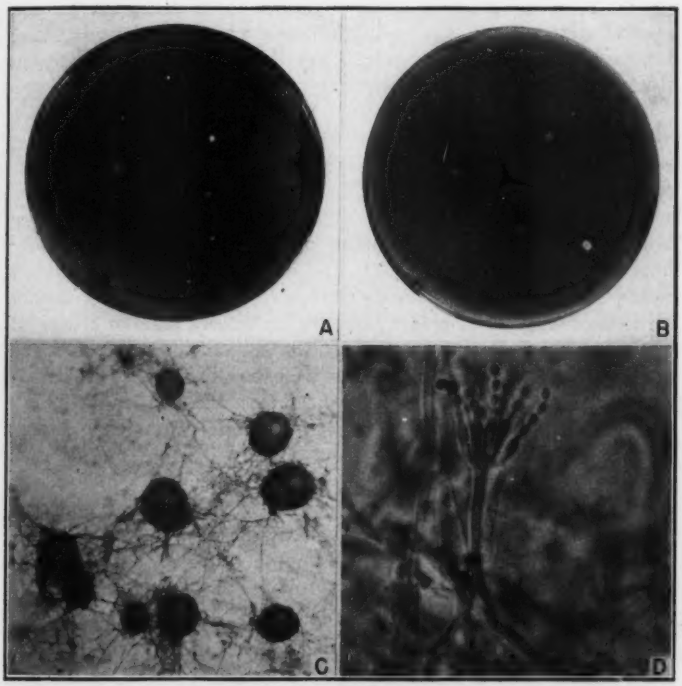

FIG. 6. *Penicillium lapidosum.*

veloping reddish tints in age, consisting of an extensive vegetative mycelium largely submerged, developing abundant orange-brown sclerotia in a fairly dense layer on the agar surface, with limited development of sterile aerial hyphae often more or less obscuring the individual sclerotia; penicilli rarely produced and not affecting the colony appearance (see hay agar below); exudate abundant, in orange-red shades; odor lacking or indistinct; reverse in orange-red shades becoming deep reddish brown in age; sclerotia globose to

subglobose, variable in size up to 300 to 350 μ in diameter (FIG. 6*C*), very hard, stony, crushing with difficulty, composed of very thick-walled polygonal cells mostly 10 to 15 μ in diameter.

Colonies on steep agar as on Czapek but growing even more rapidly, generally producing more abundant exudate, and more intensely colored reverse; penicilli very sparsely produced; sclerotia as above.

Colonies on malt agar spreading broadly, plane (FIG. 6*B*), quickly developing golden yellow shades from abundant orange colored sclerotia and enveloping yellow encrusted sterile hyphae; exudate abundant, clear; penicilli developing fairly abundantly in older colony areas but not affecting the overall appearance of the culture.

Colonies on hay infusion agar growing rapidly, thin, consisting of a spreading, submerged vegetative mycelium, producing sclerotia in limited numbers in a thin layer on the agar surface, numerous penicilli borne on short lateral branches or conidiophores from trailing hyphae; sclerotia as described above but generally smaller, rarely exceeding 200 μ in diameter; penicilli variable, mostly strictly monoverticillate (FIG. 6*D*), consisting of compact verticils of sterigmata bearing tangled or loosely parallel chains of conidia up to 100 μ in length, occasional penicilli once or twice branched and producing two or more clusters of sterigmata; conidiophores mostly 25 to 75 μ, rarely more than 100 μ in length by 2.5 to 3.0 or 3.5 μ in diameter, with walls smooth, commonly septate; branches, when present, mostly 10 to 20 μ by 2.5 to 3.0 μ, more or less divergent; sterigmata ranging from 3 or 4 up to 7 or 8 in the verticil, mostly 6.0 to 7.5 μ by about 2.0 μ with conidium-bearing tips definitely narrowed (FIG. 6*D*); conidia at first definitely elliptical, usually remaining so and ranging from 2.5 to 3.0 μ by 2.0 to 2.5 μ, occasionally subglobose, 2.0 to 2.5 μ in diameter, with walls smooth and comparatively heavy.

Species description based upon NRRL *718* as **type,** isolated in 1938 from canned blueberries by Dr. E. J. Cameron and associates, National Canners Association, Washington, D. C.

Williams, Cameron, and Williams (**1941**) reported the sclerotia of this mold to be unusually heat-tolerant, being able to withstand a temperature of 90.5° C. for thirty to forty minutes. The culture also was reported to be able to grow (or survive) in a high vacuum. These investigators reported the successful isolation of the mold from three of five soil samples collected from blueberry fields and

heated in the laboratory to 180° F. for twenty-five minutes. They failed, however, to distinguish between the form which produced ascospores (*Penicillium striatum*) and that which produced sclerotia—in fact, they apparently regarded the two strains as representing different aspects of the same fungus. Their report failed to state whether both types, sclerotial and ascosporic, were reisolated from soil or whether the sclerotial form only was so obtained.

The type strain of *Penicillium lapidosum* is characterized particularly by the abundant sclerotia which it produces. In appearance and texture, these are strongly suggestive of the young, sclerotioid perithecia which characterize certain ascosporic species such as *P. parvum* and *P. baarnense* van Beyma (**1939–1940**). At no time, however, have we observed any evidence of ascospore formation in this strain—the bodies remaining hard and sclerotioid indefinitely. The species is assigned to the sclerotigenic series of monoverticillate *Penicillia* with *P. thomii* Maire (**1917**).

An additional culture, essentially duplicating NRRL *718*, isolated at Baarn in 1939, was received from the Centraalbureau in June 1946 as *Penicillium mangini* Duché and Heim. This is now maintained in our collection as NRRL *2084*. The above cultures seem to agree reasonably well with Duché and Heim's description, in both the character of the sclerotia produced and the manner in which the penicilli are borne on trailing aerial hyphae. Furthermore, the penicilli are not consistently monoverticillate but frequently produce branched structures of the type illustrated by Duché and Heim (**1931**). Were it not for the fact that Duché, in personal conference with us in our Laboratory and with the cultures in question before him (January, 1947), indicated that his species was originally based upon a different type of organism, we would have concluded that NRRL *718* and *2084* accurately represented *P. mangini*. However, since these forms apparently do not represent his species, and since they cannot be satisfactorily assigned to any other described form, we recognize them as representing a new species to which the binomial *P. lapidosum* is assigned because of the abundant stone-like sclerotia that characterize it.

Conidial Species

Penicillium capsulatum sp. nov.

Coloniae in agaris omnibus restrictae, e coacta tenui mycelica superficie velutina vel floccosa constitutae, saepe profunde furcatae vel rugosae, sporulatione media, primum pallide griseo-virides, in culturis senibus fuscescentibus; exudato odoreque carentibus; conidiophoris ascendentibus, plerumque ex hyphis repentibus orientibus, brevissimis vel usque 100 × 2.0–2.5 μ, glabris, irregulariter ramosis; penicillis monoverticillatis, interdum caespitosis, sed distinctis; sterigmatibus in 5–10 verticillis simplicibus, compactis dispositis, plerumque parallelibus, 8.0–10.0 × 2.0–2.2 μ; conidiis ellipticis usque capsulatis, 3.0–4.0 × 2.0–2.5 μ, glabris, in columnis usque 100 μ longis vel longioribus catenatis.

In culturis ex instrumento opticali, Panama Canal Zone.

Colonies on Czapek's solution agar growing restrictedly, attaining a diameter of 2.0 to 2.5 cm. in twelve to fourteen days at room temperature, consisting of a comparatively thin, close-textured mycelial felt, tough, tearing irregularly, with surface appearing velvety or very slightly floccose, deeply furrowed (FIG. 7*A*), commonly raised or depressed in central area, azonate in most strains, with growing margin narrow, about 1 mm. wide, white, medium sporing throughout, in gray-green shades, at first approximately court gray or gnaphalium green (Ridgway, Pl. XLVII) becoming darker in age near sage green (R., Pl. XLVII), exudate lacking; odor lacking or indefinite; reverse uncolored or slightly greenish at first but later showing orange to pinkish shades; conidiophores ascending, arising primarily from creeping or interlacing hyphae (FIG. 7*C*), from very short up to 100 μ or more in length by 2.0 to 2.5 μ in diameter, walls smooth, branching irregularly, occasionally over their entire length, but more abundantly in terminal areas; penicilli monoverticillate, borne on branches of varying length and occasionally more or less clustered but consistently retaining their individual character (FIG. 7*D*); sterigmata borne irregularly but typically in simple clusters, ranging from 4 or 5 up to 8 or 10 in the verticil, usually crowded, parallel, sometimes divergent, mostly 8 to 10 μ by 2.0 to 2.2 μ but not infrequently larger or smaller; conidia strongly elliptical, commonly capsule-shaped, mostly 3.0 to 4.0 μ by 2.0 to 2.5 μ, but frequently larger, with walls smooth.

Colonies on steep agar growing more rapidly, 2.5 to 3.0 cm. in ten to twelve days, texture as described above but more strongly and deeply furrowed, heavier sporing throughout, at first near pea green becoming sage green in colony center (R., Pl. XLVII); exudate limited, pale yellow; odor sourish; reverse uncolored or

in yellow shades; conidiophores and penicilli as described above; conidia more consistently capsule-shaped.

Colonies on malt agar about 2.5 to 3.0 cm. in ten to twelve days, comparatively thin with center commonly raised, velvety, heavily sporing throughout (FIG. 7*B*), pea green to sage green, reverse in dull yellow to drab shades; conidiophores longer, up to 200 to 300 μ and loosely branched, commonly arising from the substratum, with

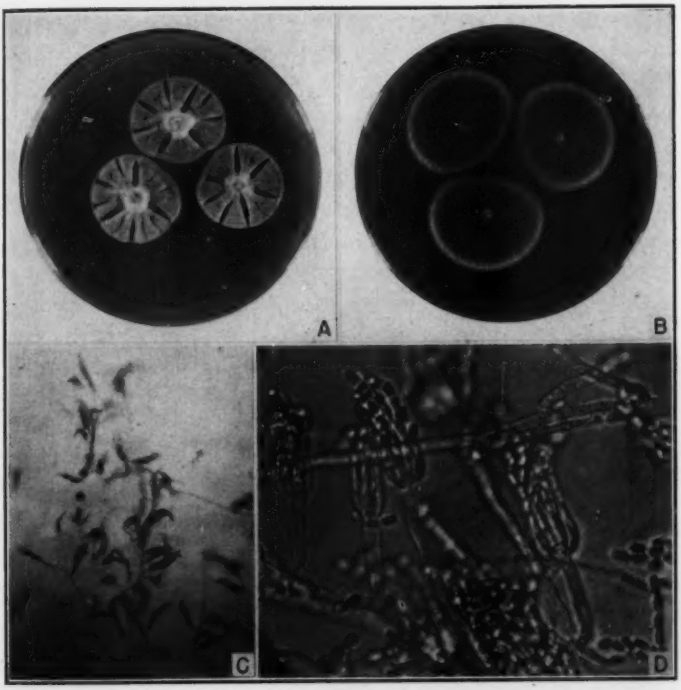

FIG. 7. *Penicillium capsulatum.*

walls smooth but appearing granular within; penicilli more regular in pattern than on Czapek or steep agar, usually consisting of a closely crowded cluster of 6 to 12 or more parallel sterigmata, 7 to 8 μ by 1.5 to 2.0 μ, bearing conidia in long parallel chains forming compact columns, about 10 μ in diameter and up to 150 μ or more in length; conidia very strongly elliptical to narrowly cylindrical, mostly 3.0 to 4.0 μ by 1.5 to 2.0 μ, occasionally up to 6.0 to 7.0 μ

by 2.0 to 3.0 μ, with walls smooth, adhering in long chains when viewed in fluid mounts.

The binomial *Penicillium capsulatum* is assigned to the species because of the characteristic strongly elliptical to narrowly cylindrical form of its conidia which duplicate in pattern the gelatin capsules used in pharmaceutical trade.

Species description centered upon NRRL *2056* as **type**, received in September 1945, from Professor W. H. Weston, Harvard University, as a culture isolated in the Panama Canal Zone from an optical instrument by Dr. W. G. Hutchinson. It is duplicated also by NRRL *2057*, received in May 1945, from Dr. W. Lawrence White, Philadelphia Quartermaster Depot, as a strain isolated from exposed canvas in the Gilbert Islands.

Additional strains representing this species have been repeatedly encountered among the molds isolated from deteriorating military equipment in tropical and sub-tropical areas. No information is available regarding the extent of growth or the amount of damage caused by this organism, but its repeated isolation from such sources would seem to indicate its probable wide distribution in tropical and sub-tropical areas.

Penicillium lavendulum sp. nov.

Coloniae in agaro Czapekii late effusae, comparative tenues, mycelio vegeto plurimum submerso, superficiali laxo vel flocculento et funiculoso; fructificatione in areas centrales densa, griseo-lavendula, margine incolorata, in agaro maltoso abundanti, vinacea; reverso purpureo-vinaceo; conidiophoris e substrato vel hyphis repentibus orientibus, fere 100–150 × 3.0–3.5 μ, conspicue echinulatis; penicillis asymmetricis infra metulas 1–2 ramosis, ramis variabilibus, usque 15–20 × 2.5–3.0 μ, valde echinulatis; metulis 8.0–10.0 × 2.0–3.0 μ, plerumque echinulatis; sterigmatibus strictim parallelibus, dense confertis, 7.0–9.0 × 2.0–2.2 μ, saepe asperatis; conidiis ellipticis, variabilibus, 3.0–4.5 × 2.0–3.0 μ, glabris, in catenis longis saepe laxe parallelibus.

Contaminatione in laboratorio, Peoria, Illinois.

Colonies on Czapek's solution agar spreading broadly, attaining a diameter of 5.0 to 6.0 cm. in twelve to fourteen days at room temperature, plane or nearly so, azonate, comparatively thin with vegetative mycelium largely submerged and with surface growth consisting of a loose weft of flocculent to cottony hyphae, showing some ropiness mostly in marginal to submarginal areas, sporulating abundantly in central areas (FIG. 8*A*), approximating dark

grayish lavender to Ramier blue (Ridgway, Pl. XLIII), thinning through lighter shades to uncolored at the colony margin; exudate limited, in small drops, colorless; odor slight; reverse uncolored to light purple; penicilli variable in size, with conidial chains up to 100 μ in length, loosely parallel, tangled or matted (FIG. 8*C*); co-

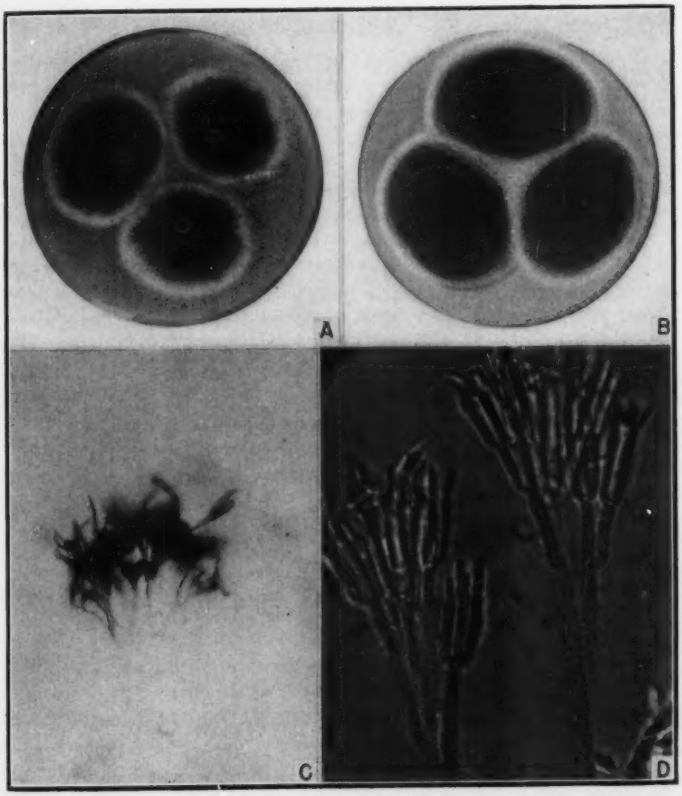

FIG. 8. *Penicillium lavendulum.*

nidiophores sometimes arising from the substratum, but borne primarily as branches from aerial hyphae, commonly 100 to 150 μ in length by 3.0 to 3.5 μ in diameter, sometimes shorter, septate, with walls closely echinulate; penicilli asymmetrical, irregularly once- or twice-branched below the metulae, with metulae commonly arising at different levels within the penicillus; branches mostly

2.5 to 3.0 μ in diameter, varying greatly in length up to 15 to 20 μ, rough; metulae mostly 8 to 10 μ by 2.5 to 3.0 μ, usually roughened (FIG. 8*D*); sterigmata in compact clusters, closely parallel, 7 to 9 μ by 2.0 to 2.2 μ, with apices slightly narrowed but lacking well-defined conidium-bearing tubes, commonly rough-walled; conidia narrowly elliptical (FIG. 8*D*), from 3.0 to 4.5 μ by 2.0 to 3.0 μ, with walls smooth and comparatively heavy, tending to adhere in chains in fluid mounts.

Colonies on steep agar growing as on Czapek but somewhat deeper and generally heavier sporing, predominantly dark grayish lavender but often appearing somewhat mottled from irregular spore production in submarginal areas; reverse in purple-vinaceous shades, thinning toward the margin; penicilli as described above but commonly larger, with cellular elements somewhat longer; conidia more narrowly elliptical, capsule-shaped.

Colonies on malt extract agar broadly spreading, plane, like the preceding in pattern and texture but usually heavier sporing, with massed penicilli forming crusts of conidia up to 400 or 500 μ deep (FIG. 8*B*), developing reddish tints to form shades near deep purplish vinaceous to dull Indian purple (R., Pl. XLIV); reverse in dull to deep purple vinaceous shades; conidiophores arising mainly from the substratum; penicilli as described above but commonly larger and more complex, up to 50 or 60 μ in length, with walls of conidiophores, branches, and metulae conspicuously roughened; conidia narrowly elliptical or capsule-shaped, 4.0 to 4.5 μ by 2.0 to 2.5 μ, smooth-walled.

Species description based upon NRRL *2146* as **type**, isolated in July 1947 as a laboratory contaminant at the Northern Regional Research Laboratory.

The binomial *Penicillium lavendulum* is based upon the characteristic coloring of the species upon Czapek's solution and steep agars.

The correct placement of the species remains in doubt, but it appears to be most satisfactorily assignable to a series with *Penicillium pallidum* Smith (**1933**) in the Funiculosa subsection of the Asymmetrica. The conspicuously roughened conidiophores and cellular elements of the penicilli, its narrowly elliptical to capsule-shaped conidia, and the funiculose character of its colonies on Czapek's agar all tend to relate it to this series more closely than to any other recognized group. Furthermore, colonies on malt agar occasionally develop limited sectors or overgrowths character-

ized by almost colorless conidia, and isolations made from such areas commonly show little or no pigmentation of conidia. In gross appearance these substrains are often strongly suggestive of the species *P. pallidum*.

Bainier (**1906**) described a species, *Penicillium rubescens*, characterized by narrowly elliptical conidia with fruiting areas in reddish or rusty shades. Penicilli were described and figured as complex and repeatedly branched, with cellular elements coarse and very short. In *P. lavendulum*, however, cellular elements are quite long and thin and the penicilli commonly appear somewhat laterally appressed. Were it not for such marked differences in the general patterns of the penicilli of the two forms, our culture might possibly be regarded as representing Bainier's species.

Penicillium piceum sp. nov.

Coloniae in agaro Czapekii tenues, mycelio vegeto plurimum submerso vel e coacta laxa aerea, satis funiculosa constitutae, fructificationes conidicas paucas vel abundantes gerentes, sordide flavo-virides, reverso rubro-aurantio usque rubro-brunneo; guttulis microscopicis abundantibus; conidiophoris glabris, brevibus, rare 50×2.5–$3.0\ \mu$ excedentibus, rete hypharum multo ramosarum orientibus; penicillis dense compactis, biverticillatis et symmetricis, metulis 10–12, verticillis densis sterigmatium et catenarum conidicarum compositis et massam conicam vel pyramidalem usque $150\ \mu$ longam efformantibus; metulis 8–10×1.8–$2.2\ \mu$, exterioribus incurvatis; sterigmatibus lanceolatis apicibus acuminatis, 8–9×1.5–$1.8\ \mu$, parallelibus, catenas conidiorum strictim adherentes gerentibus; conidiis subglobosis vel ellipticis, 2.5–3.0×2.2–$2.8\ \mu$, primum glabris, saepe in aetate irregulariter asperatis.

In cultura indeterminata, Thom Collection.

Colonies on Czapek's solution agar growing somewhat restrictedly (FIG. 9*A*), attaining a diameter of 3.0 to 3.5 cm. in twelve to fourteen days at room temperature, often with central area 1.0 to 1.5 cm. raised, consisting primarily of a thin, white to yellow mycelial felt bearing few conidial heads but surrounded by a thinner plane marginal zone producing abundant conidial structures in a loose mycelial network, in dull yellow-green shades near tea green or pea green (Ridgway, Pl. XLVII), occasional strains lacking the prominent thin margin, but showing the entire colony area felted, producing limited numbers of conidial structures and considerable sterile mycelium throughout; exudate fairly abundant, mostly as microscopic droplets adherent to the mycelium; odor distinct, rather pleasant; reverse in brownish orange shades, with the green of conidial areas showing through in marginal areas; conidiophores

short (FIG. 9*D*), arising from a loose network of much-branched aerial hyphae, usually about 20 to 35 μ by 2.5 to 3.0 μ, rarely 50 μ or more, in length, smooth-walled; penicilli very compact, typically biverticillate-symmetrical (FIG. 9*E*), consisting of 10 to 12 metulae borne on the vesicular apices of the conidiophores; metulae 8 to 10 μ by 1.8 to 2.2 μ, with outer metulae incurved, tending to become parallel with the main axis of the conidiophore; sterigmata

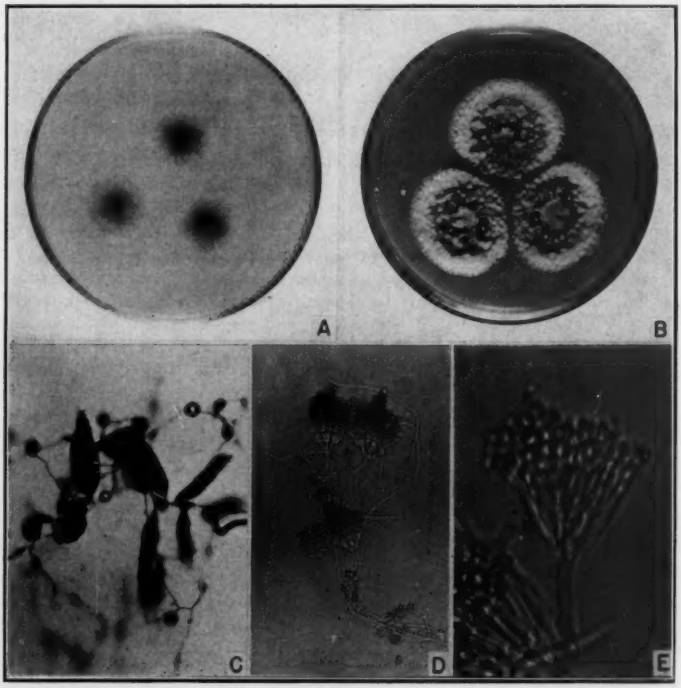

FIG. 9. *Penicillium piceum.*

typical of the Biverticillata-Symmetrica, lanceolate with apices acuminate, parallel, occurring in crowded clusters of 5 to 7, 8.0 to 9.0 μ by 1.5 to 1.8 μ, producing conidia in closely adherent chains which consistently produce conical to pyramidal masses up to 150 μ long (FIG. 9*C*); conidia subglobose to elliptical, 2.5 to 3.0 μ by 2.2 to 2.8 μ, smooth when young, becoming heavy-walled and irregularly roughened when mature, dark olive-green in mass, chains adherent

and the masses of conidia retaining their conical shape even in liquid mounts.

Colonies on steep agar growing rapidly, 5.0 to 5.5 cm. in twelve to fourteen days at room temperature, plane, velvety in appearance but consisting of a loose network of dwarfed aerial hyphae, heavily sporing throughout in dull yellow-green shades near slate-olive (R., Pl. XLVII), surface of colonies overgrown to a greater or lesser degree by sterile encrusted yellow mycelium becoming conspicuous in some strains; exudate limited to abundant, in small droplets, clear to very light yellow; odor as on Czapek; reverse in orange or red-brown shades becoming almost black in older areas; details of penicilli as described in Czapek, but with masses of conidia less conspicuously cone-shaped and up to 200 μ in length.

Colonies on malt extract agar 4.5 to 5.0 cm. in diameter in twelve to fourteen days (FIG. 9*B*), 1 to 2 mm. deep, surface uneven from irregular tufts of encrusted funiculose hyphae; fairly heavily sporing, in yellow-green shades near vetiver to andover green (R., Pl. XLVII); exudate limited in amount, evaporating to leave pits in the colony surface; odor fragrant, faintly suggestive of apples; reverse uncolored or showing very slight orange tints; microscopic details as on Czapek.

Species description centered upon NRRL *1051* as **type,** from the Thom Collection as an unidentified culture. Duplicated by NRRL *1071* received in 1937 from C. W. Emmons, National Institute of Health, as an unidentified *Penicillium;* and NRRL *2112,* received in 1945 from J. W. Groves, Ottawa, Canada, as an unidentified *Penicillium* isolated from alfalfa seed.

Careful consideration of all described species of *Penicillium* has failed to reveal one which adequately characterizes the above strains. We, therefore, regard the cultures in question as representing a new species, to which the binomial *Penicillium piceum* is applied because of the striking resemblance of the typical conidial head to a compact, spruce-like evergreen in miniature.

The species clearly belongs in the Biverticillata-Symmetrica section and is most satisfactorily assigned to the series with *Penicillium funiculosum* Thom (**1910**).

Penicillium aculeatum sp. nov.

Coloniae in agaro Czapekii restrictae, coacta mycelica superficie velutina corrugata conpositae, sporulatione media, flavido-viridae et saepe ex hyphis rubris supercretae, reverso vinaceo vel purpureo-rubro, in agaro maltoso late

crescentes, sporulatione densa, flavido-virides; conidiophoris e substrato vel coacta mycelica orientibus, 50–200 vel longioribus × 3.0–4.0 μ, parietibus granulosis vel conspicue asperatis; penicillis comparative brevibus, typice biverticillatis et symmetricis, interdum non ab omni parte; metulis inflatis, 8.0–12.0 × 4.5–5.5 μ; sterigmatibus 7.0–9.0 × 3.0–3.5 μ, saepe tumidis, apicibus acuminatis; conidiis globosis vel subglobosis, 3.0–3.5 μ in diam., crasse tunicatis et conspicue echinulatis, in catenis laxe parallelibus vel implicatis usque 150 μ longis.

In culturis e textile ad aerem exposito, Florida.

Colonies on Czapek's solution agar growing restrictedly (FIG. 10*A*), about 2 cm. in twelve to fourteen days at room temperature, consisting of a tough basal felt 1 to 2 mm. deep, often buckled and wrinkled, sometimes irregular in outline, medium sporing and velvety in appearance in central colony areas, developing yellow-green shades near celandine to artemisia green (Ridgway, Pl. XLVII), often with a pinkish cast from a limited overgrowth of red-pigmented hyphae and embedded droplets of exudate; growing margins 2 to 3 mm. wide, white to slightly pink, often appearing somewhat tufted or funiculose; exudate abundant, almost uncolored to definitely vinaceous, occurring in small droplets and often becoming overgrown by conidial areas as these develop; odor almost lacking; reverse in vinaceous or purplish red shades approximating mineral red to dark mineral red (R., Pl. XXVII) in older areas, not strongly discoloring the surrounding agar; conidiophores arising primarily from the mycelial felt, short, commonly about 50 μ, rarely up to 100 μ by 3.5 to 4.0 μ, with walls appearing somewhat granular; penicilli typically biverticillate and symmetrical but with fractional or monoverticillate structures commonly produced; metulae 8 to 12 μ by 4.5 to 5.5 μ, usually appearing definitely inflated; sterigmata 7 to 9 μ by 3.0 to 3.5 μ, often appearing somewhat swollen; conidia globose to subglobose, 3.0 to 3.5 μ in diameter, with walls comparatively heavy and conspicuously echinulate (FIG. 10*C*), borne in loosely parallel or tangled chains 75 to 100 μ in length.

Colonies on steep agar growing somewhat restrictedly but more rapidly than on Czapek, radially furrowed with center somewhat raised, medium sporing throughout, in dull yellow-green colors as above but with reduced development of pink aerial hyphae and an almost complete absence of pink exudate, growing margin about 1 mm. wide, white; reverse usually in lighter shades than on Czapek; conidial structures generally intermediate in pattern between those developed on Czapek and on malt agar.

Colonies on malt agar spreading broadly, up to 5.5 to 6.0 cm. in twelve to fourteen days, plane (FIG. 10*B*), heavily sporing throughout, in dark yellow-green shades near Lincoln green to dusky

olive-green (R., Pl. XLI); conidiophores arising primarily from the substratum, less commonly from trailing or ascending hyphae, mostly about 200 μ long, but ranging from 100 to 300 μ or more by about 2.5 to 3.0 μ in diameter, with walls commonly roughened; penicilli comparatively short, consisting of a terminal verticil of metulae bearing clusters of somewhat divergent sterigmata, but

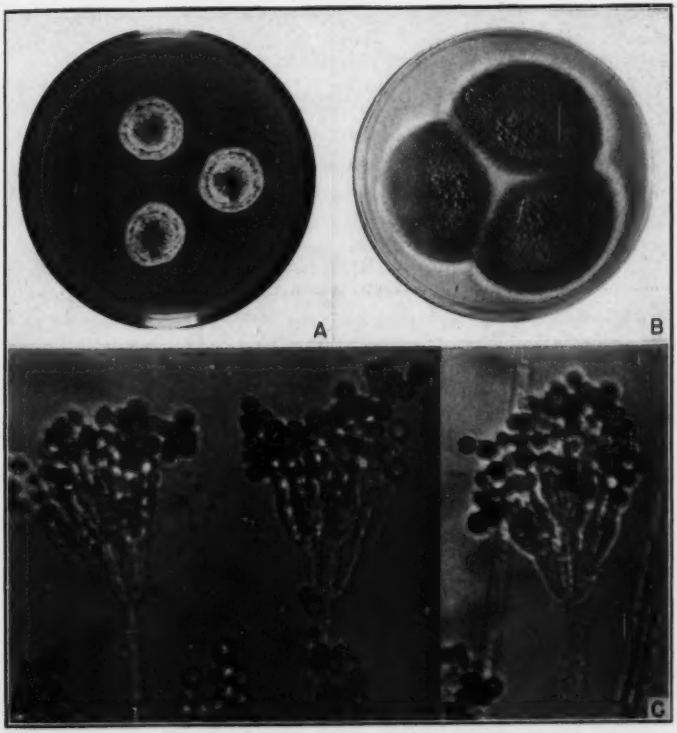

FIG. 10. *Penicillium aculeatum.*

withal typical of the Biverticillata-Symmetrica section of the genus (FIG. 10*C*); metulae occurring in verticils of 5 to 9, each bearing a crowded cluster of 5 to 7 sterigmata with finely granular walls and with strongly tapered conidium-bearing tips; conidia globose to subglobose, 3.0 to 3.5 μ in diameter, conspicuously echinulate, dark olive-green in mass, occurring in loosely parallel or tangled chains 100 to 150 μ in length.

Species description based upon a number of strains received from Professor William H. Weston, Harvard University, as unidentified cultures isolated from canvas and other materials infected during exposure tests in Florida. NRRL *2129* and NRRL *2130* (**cotypes**) are representative. The species is regarded as new since careful examination of the literature has failed to reveal any described form which produces (1) globose and conspicuously rough conidia and (2) strongly roughened conidiophores in colonies with deep red colors in reverse.

The species name is taken from the Latin *aculeatus* (meaning "prickly"), and is applied because of the conspicuously echinulate character of conidia, and the roughened walls seen in conidiophores, metulae, and even sterigmata on malt extract agar where the species makes its maximum development.

Penicillium aculeatum is tentatively assigned to the *P. purpurogenum* series. Such placement is based upon two primary considerations: (1) colonies are more or less restricted on Czapek's solution and steep agars and produce a rich red to purple-red color in reverse, and (2) colonies on malt agar are broadly spreading, heavily sporing throughout, dark yellow-green in color, and essentially velvety. It differs from the other members of this series in producing conidial structures with walls often roughened and with conidia strongly echinulate and *globose* rather than elliptical to subglobose. Elements of the penicillus are usually shorter and tend to be divergent rather than closely parallel. In this latter characteristic the species resembles *P. verruculosum* Peyronel (**1913**), which also produces rough, globose conidia. The comparatively short, broad penicilli are suggestive of *P. herquei* Bainier and Sartory (**1912**) but the species shows litle additional evidence of relationship in that direction. *Penicillium aculeatum* is separated from the *P. funiculosum* Thom (**1910**) and related species by an absence or limitation of funiculose hyphae. It is separated from *P. rugulosum* Thom (**1910**) by the production of abundant red to purple-red color in colony reverse, and by the character of its conidia. Despite the fact that the species does not conform too closely with other members of the *P. purpurogenum* series, it is our belief that workers encountering this species in culture will locate it here more conveniently than elsewhere.

Penicillium diversum sp. nov.

Coloniae in agaro Czapekii neutro pertenues et multo restrictae, in agaro Czapekii acido et maltoso celeriter crescentes, luxuriosae, comparative tenues, planae, saepe anguste zonatae, sporulatione per omnes partes densa, griseae usque olivaceo-griseae; exudato carenti, reverso incolorato; conidiophoris e substrato orientibus, 200–300 × 2.0–2.5 μ, glabris; penicillis biverticillatis et symmetricis, 5–8 metulis in verticillo terminali compositis; metulis 9–11 × 2.0–2.5 μ, sursum leniter inflatis; sterigmatibus 6–8, dense caespitosis, lanceolatis, apicibus acuminatis, 8–10 × 1.8–2.2 μ; conidiis ellipticis, 2.0–2.5 × 1.5–2.0 μ, glabris vel delicate asperatis, in catenis laxe parallelibus usque 200 μ longis.

In culturis e corio mucoso, Philadelphia, Pa.

Colonies on Czapek's solution agar extremely slow-growing (FIG. 11*A*), 2 to 5 mm. in twelve to fourteen days at room temperature, thin or consisting of a fairly tough mycelial felt, surface appearing velvety or slightly granular, medium sporing in yellow-green shades near Andover green (Ridgway, Pl. XLVII); exudate lacking; odor suggesting sea-weed; reverse uncolored; conidiophores arising from the mycelial felt, up to 200 μ by 2.0 to 2.5 μ, with walls smooth or nearly so; penicilli typically biverticillate and symmetrical (FIG. 11*C*), regularly consisting of a terminal verticil of 5 to 7 or 8 metulae measuring about 9 to 11 μ by 2.0 to 2.5 μ, slightly enlarged upward; sterigmata usually in compact clusters of 6 to 8, mostly 8 to 10 μ by 1.8 to 2.2 μ; conidia at first elliptical, becoming subglobose or broadly elliptical when mature, with walls thin, smooth or delicately roughened, mostly 2.0 to 2.5 μ by 1.5 to 2.0 μ, borne in tangled chains up to 75 or 100 μ in length.

Colonies on steep agar essentially as on Czapek but usually lighter sporing, conidial structures sparsely produced, often smaller than on Czapek.

Colonies on malt extract agar spreading broadly, up to 5.0 to 5.5 cm. in twelve to fourteen days, velvety, plane, with vegetative mycelium largely submerged, bearing abundant conidial structures in a dense stand (FIG. 11*B*), consistently narrowly zonate, heavily sporing throughout in dull gray shades near grayish olive (R., Pl. XLVI); showing abundant short, encrusted and pigmented hyphae intermixed with conidial structures; exudate lacking; odor not pronounced, slightly musty; reverse uncolored; conidiophores up to 300 μ in length; penicilli as described on Czapek but generally showing metulae and sterigmata slightly longer; conidia in loosely parallel chains up to 200 μ in length.

Colonies on Czapek's solution agar containing ammonium sulfate (2.33 g./liter) as the nitrogen source approximating those on malt in rate of growth, general texture, and in the abundance of conidial structures produced; conidial areas near Andover green (R., Pl.

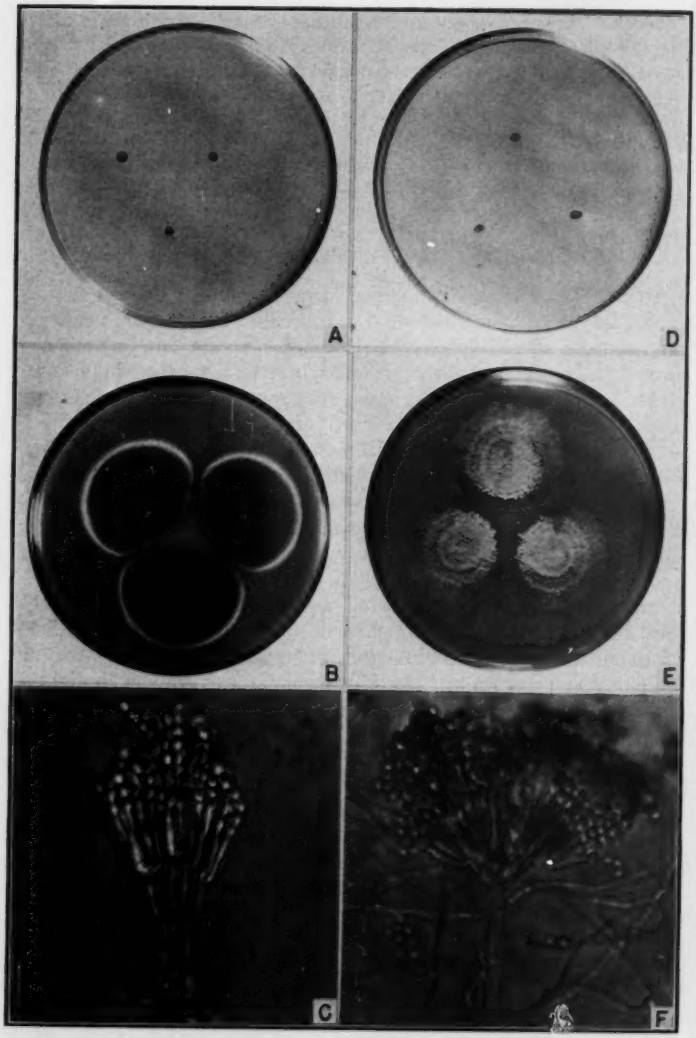

FIG. 11. *Penicillium diversum* and var. *aureum*.

XLVII), showing a limited development of sterile, yellow-pigmented aerial hyphae in submarginal areas; exudate lacking; odor indistinct; reverse uncolored; penicilli as described on malt agar.

Species description centered upon NRRL *2121* as **type,** isolated from moldy leather and submitted to us for identification by Dr. T. C. Cordon, Eastern Regional Research Laboratory; and NRRL *2122,* isolated from soil collected in Sweden and contributed by Professor Edy Velander, Stockholm. The species is represented by numerous additional strains isolated from deteriorating military equipment, dried egg powder, and soils.

This species is placed in the series with *Penicillium tardum* Thom (**1930**) primarily because of its very restricted growth upon standard Czapek and steep agars that are neutral in reaction and contain sodium nitrate as the principal nitrogen source. The fact that the species grows luxuriantly upon malt extract agar and upon Czapek's solution agar containing ammonium sulfate clearly demonstrates the presence of some nutrient deficiency. The species is favored by a reaction of pH 4.0 to 6.0, but grows very sparsely and fails to sporulate at pH 7.0. Recognition of the species as new is based not upon its inability to utilize nitrate nitrogen, but upon its failure to duplicate any recognized species even upon favorable media, such as malt extract agar, or Czapek agar containing ammonium nitrogen, where it grows luxuriantly. The species is clearly different from *Penicillium tardum* Thom: penicilli are more consistent in pattern; conidia are smaller, less definitely elliptical, thin-walled, and smooth; and colonies upon favorable media are spreading, plane, heavy sporing, velvety, and narrowly zonate.

The binomial, *Penicillium diversum* (from the Latin word *diversus*), is based upon the markedly different growth of this species upon different substrata.

Penicillium diversum var. **aureum** var. nov.

Colonies on Czapek's solution and steep agars duplicating those of the species in color, texture, and rate of growth (FIG. 11*D*); producing a fairly dense stand of conidial structures which differ

from the species in showing metulae and sterigmata more numerous in the verticil and usually somewhat shorter.

Colonies on malt agar duplicating those of the species in rate of growth but differing markedly in color and texture (FIG. 11*E*), approximating olive-yellow to olive-ocher (Ridgway, Pl. XXX), appearing somewhat granular or tufted, especially in marginal areas, and consisting of a comparatively thin, closely interwoven network of yellow encrusted, much-branched, sterile hyphae enmeshing and largely obscuring numerous conidial structures; penicilli biverticillate and symmetrical, short and very compact (FIG. 11*F*), bearing metulae in large crowded clusters of 12 to 15 or more, individually measuring about 7 to 8 μ by 1.5 to 1.8 μ; sterigmata in verticils of 6 to 8, about 7.5 to 9.0 μ by 1.5 μ, lanceolate with characteristically tapered tips; metulae and sterigmata usually yellowish green in color; conidia elliptical to subglobose, mostly 2.4 to 2.8 μ by 2.0 to 2.5 μ with walls comparatively thin, smooth or nearly so, in yellow-green shades.

The varietal name is based upon a characteristic yellow coloration upon certain media that are unusually favorable for growth, including malt extract and Sabouraud's agars. The yellow variety differs from the typical variety in two outstanding characteristics: (1) The production of greatly increased amounts of yellow encrusted mycelium, and (2) the production of larger penicilli consisting of substantially greater numbers of metulae and sterigmata.

Growth is more luxuriant when cultivated upon media containing ammonium rather than nitrate nitrogen and it is greater on acid than neutral substrata. The variety does not grow as well upon Czapek agar containing ammonium sulfate as upon malt agar. It does, however, seem to possess the same basic nutritional deficiencies as the species.

The variety is represented by NRRL *1074* as **type**, received in 1934 from Ross W. Davidson, Division of Forest Pathology, Bureau of Plant Industry. The strain was initially diagnosed as *Penicillium tardum* Thom upon the basis of its symmetrically biverticillate penicilli and its restricted growth upon Czapek's agar. The subsequent discovery and recognition of *P. diversum* showed the probable relationship of the variety to be with the latter species rather than with *P. tardum* Thom.

SUMMARY

Eleven species and one variety of *Penicillium* are described as new. The new forms include:

1. Five ascosporic species:
   a. *Penicillium parvum* and *P. levitum* produce monoverticillate penicilli and perithecia that are at first pseudoparenchymatous throughout. They are assignable to the ascosporic series typified by *P. javanicum* v. Beyma.
   b. *Penicillium rotundum* and *P. helicum* unmistakably represent members of the *P. luteum* series and produce soft, loose-textured perithecia. Conidial structures, although often fractional, are typically biverticillate and symmetrical with lanceolate sterigmata.
   c. *Penicillium striatum* produces perithecia of the type characteristic of the *P. luteum* series, but fails to develop either symmetrical penicilli or lanceolate sterigmata. Its relationship is somewhat doubtful.
2. One sclerotigenic species, *Penicillium lapidosum,* with penicilli typically monoverticillate. It is closely related to *P. thomii* Maire.
3. Five non-ascosporic species and one variety:
   a. *Penicillium capsulatum* with monoverticillate penicilli borne on short branches from ascending hyphae, hence assignable with other ramigenous species.
   b. *Penicillium lavendulum* produces asymmetric penicilli with cellular elements conspicuously echinulate; it is assignable to the Asymmetrica-Funiculosa near *P. pallidum* Smith.
   c. *Penicillium piceum, P. aculeatum, P. diversum,* and *P. diversum* var. *aureum* represent members of the Biverticillata-Symmetrica section. These are assignable to series typified by the well-recognized species, *P. funiculosum* Thom, *P. purpurogenum* Stoll, and *P. tardum* Thom, respectively.

The writers are indebted to Dr. Charles Thom for his counsel and advice relative to the validity and relationships of these species; and to Miss Edith K. Cash for preparing the Latin diagnoses.

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EXPLANATION OF FIGURES

FIG. 1. *Penicillium parvum;* NRRL *2095*. *A* and *B*, Two-week-old colonies on Czapek's solution and hay infusion agars, respectively. *C*, Low-power view of perithecia on corn meal agar, × 60. *D*, Ascospores, × 1500; note small dimensions and prominent equatorial ridges and furrows.

FIG. 2. *Penicillium levitum;* NRRL *705*. *A* and *B*, Two-week-old colonies on Czapek's solution and malt agar, respectively. *C*, Detail of penicilli, which are typically monoverticillate and often fractional, × 800. *D*, Broken perithecia showing ascogenous masses extruded by pressure of the coverglass, × 85. *E*, Asci in various stages of development. *F*, Ascospores, × 1500; note comparatively heavy, smooth walls.

FIG. 3. *Penicillium helicum;* NRRL *2106*. *A*, Ten-day-old colonies on malt extract agar. *B*, Initial stage in perithecium development; note the thick hypha (ascogonium?) with terminal area coiled in characteristic fashion, and (*b*) the smaller hypha (antheridium?) wound around the basal portion of it. *C*, Perithecia as developed on malt extract agar, × 30. *D*, Ascospores, × 1500; the delicately spinulose character of the spore walls is not shown.

FIG. 4. *Penicillium rotundum;* NRRL *2107*. *A*, Ten-day-old colonies on malt extract agar. *B*, Initial stage in perithecium development; unlike *P. helicum*, this species shows no regularity in pattern and fails to develop consistent structures identifiable as possibly representing ascogonia and antheridia. *C*, Perithecia as developed on malt agar, × 30. *D*, Ascospores, × 1500; note characteristic globose form and conspicuously roughened walls.

FIG. 5. *Penicillium striatum;* NRRL *717*. *A* and *B*, Two-week-old colonies on Czapek's solution and malt extract agars, respectively. *C*, Conidial stage: C_1, penicilli as seen under low power, × 100; C_2, detail of penicilli showing cellular patterns and arrangements, × 800; C_3, mature conidia, × 800. *D*, Perithecium compressed by a coverglass, showing extrusion of asci through the surrounding loose hyphal envelope, × 450. *E*, Asci, showing the manner in which these are borne singly on short branches from the fertile hyphae, × 900. *F*, Ascospores, showing the prominent longitudinal frills which characterize this species, × 900.

FIG. 6. *Penicillium lapidosum;* NRRL *718*. *A* and *B*, Two-week-old colonies on Czapek and malt agars, respectively. *C*, Sclerotia as seen on corn meal agar, × 65. *D*, Detail of penicillus, × 900.

FIG. 7. *Penicillium capsulatum;* NRRL *2056*. *A* and *B*, Two-week-old colonies on Czapek and malt agars, respectively. *C*, Low-power view showing origin of conidial structures from ascending hyphae, × 100. *D*, Detail of penicilli, × 900.

FIG. 8. *Penicillium lavendulum;* NRRL *2146*. *A* and *B*, Two-week-old colonies on Czapek and malt agars, respectively. *C*, Low-power view of penicilli on malt agar, × 75. *D*, Detail of penicilli, × 900.

FIG. 9. *Penicillium piceum;* NRRL *1071.* *A* and *B,* Ten-day-old colonies on Czapek and malt agars, respectively. *C,* Conidial heads as seen under low-power presenting the spruce-tree-like pattern that is characteristic of this species, and from which the name is taken, × 115. *D* and *E,* Penicilli under successively increased magnification, showing origin and details of structure, × 190 and × 900, respectively.

FIG. 10. *Penicillium aculeatum;* NRRL *2130.* *A* and *B,* Ten-day-old colonies on Czapek and malt agars, respectively. *C,* Detail of penicilli, showing rough conidiophores and globose, conspicuously roughened conidia, × 1000.

FIG. 11. *A–C, Penicillium diversum;* NRRL *2121.* *A* and *B,* Ten-day-old colonies on Czapek and malt agars, respectively. *C,* Detail of penicillus, × 900. *D–F, Penicillium diversum* var. *aureum;* NRRL *1074.* *D* and *E,* Ten-day-old colonies on Czapek and malt agars, respectively. *F,* Detail of penicillus, showing numerous metulae, × 700.

STUDIES IN THE GASTEROMYCETES: XVI. THE GEASTRACEAE OF THE SOUTH-WESTERN UNITED STATES

W. H. Long and David J. Stouffer

(with 32 figures)

This paper is a report on plants belonging to the family Geastraceae collected over a period of several years, mainly by us, in the states of Arizona, New Mexico and Texas.

KEY TO GENERA

1. Endoperidium with a prominent sterile base.....*Terrostella*
1. Endoperidium without a sterile base.....2
2. Endoperidium normally with one mouth, persistent.....3
2. Endoperidium normally with several mouths.....*Myriostoma*
2. Endoperidium caducous, with a persistent subligneous columella. *Trichaster*
3. Columella present, threads of capillitium simple.....*Geaster* *
3. Columella none, the threads of capillitium much branched.....*Astraeus*

The genus *Trichaster* has not yet been found in this region; hence only the four remaining genera are discussed in this paper.

All of the descriptions and photographs used in this article were made from dried herbarium material, since we rarely find any fresh "green" plants in our hot, semi-arid region; furthermore the "green" plants are not satisfactory for taxonomic purposes since they normally do not show many of the salient characters found in the usual herbarium material which we have had to use in comparing and differentiating the various species.

GEASTER Mich. Nova Plantarum Genera, p. 220. 1729

Sporophore hypogeous or epigeous, globose to acuminate; *exoperidium* of three well defined layers, an outer mycelial layer, a mid-

* The late Dr. Long did not follow the *International Rules* and consequently did not recognize Persoon's Syn. Meth. Fungorum as the starting point for the nomenclature of this genus. The correct spelling and citation for the genus in accordance with the Rules is *Geastrum* Pers., Syn. Method. Fung., p. 131. 1801.—Editor.

dle fibrillose layer and an inner collenchyma one, at first closely investing the endoperidium, at maturity splitting in a stellate manner. *Endoperidium* sessile or pedicellate, usually dehiscing by a single apical mouth. *Columella* present or lacking in the mature stage. *Capillitium* threads usually simple, long and tapering. *Spores* globose to subglobose. *Epispore* smooth or verrucose (Adapted from Kambly and Lee).

This paper reports three species of *Geaster* not previously known in the United States; namely *G. Hariotii, G. elegans* and *G. Hieronymi,* also two new species, *G. pluriosteus* and *G. xylogenus.*

KEY TO SPECIES OF GEASTER DISCUSSED IN THIS PAPER

1. Mouth sulcate....2
1. Mouth fibrillose....5
1. Mouth naked....7
2. Plants strongly hygroscopic, spore sac sessile....1. *Geaster Drummondii*
2. Plants not hygroscopic....3
2. Plants subhygroscopic....4
3. Mouth long beaked, pedicel slender....2. *G. pectinatus*
3. Mouth long beaked, base of spore sac with a collar-like ring. 3. *G. Bryantii*
3. Mouth short beaked, pedicel short, thick....4. *G. Schmidelii*
3. Plants medium size, explanate, spore sac sessile....5. *G. Hariotii*
3. Plants small, spore sac sessile, vaulted....6. *G. elegans*
3. Spore sac with several mouths—smooth....7. *G. pluriosteus*
3. Spore sac subsessile, densely furfuraceous, rays truncate..8. *G. xerophilus*
4. Spore sac smooth, mouth flattened conical, sulcate-striate..10. *G. Smithii*
4. Spore sac rough, asperate....9. *G. campestris*
4. Plants subsessile, subsaccate, spore sac smooth....13. *G. arenarius*
5. Plants strongly hygroscopic, spore sac sessile....11. *G. mammosus*
5. Plants not hygroscopic....6
6. Plants medium size, epixylous, epigeous....12. *G. xylogenus*
6. Plants small, sessile, saccate, tomentose....14. *G. tomentosus*
6. Plants pedicellate, smooth, 8–12 rays....15. *G. minimus*
6. Plants small, 4–5 rays, fornicate....16. *G. coronatus*
6. Plants typically large, spore sac strongly asperate....17. *G. Hieronymi*
6. Plants large, spore sac smooth with apophysis....18. *G. limbatus*
6. Plants small to medium, spore sac sessile, saccate. 19. *G. saccatus* form *minor*
6. Plants large to medium, subsaccate, rays acuminate....20. *G. triplex*
6. Plants medium size to small subsaccate, rays acuminate. 21. *G. saccatus* form *major*
7. Plants strongly hygroscopic, spore sac sessile....25. *G. floriformis*
7. Plants strongly hygroscopic, spore sac sessile, mouth a torn aperture. *Astraeus hygrometricus*
7. Plants not hygroscopic....8

8. Rays 4–5, plant pedicellate, fornicate..... ..22. *G. fornicatus*
8. Rays 5–6, plants large, explanate with hypophysis.....23. *G. rufescens*
8. Plants small to medium, subsaccate, sessile.....24. *G. fimbriatus*

1. GEASTER DRUMMONDII Berk. Lond. Jour. Bot. **4**: 63. 1845 (FIG. 1)

Sporophore hypogeous with a universal mycelium, becoming superficial and expanded at maturity, then 2–3 cm. in diameter. *Exoperidium* revolute when wet, split nearly to middle. *Rays* 8–10, subequal, acute, rigid, strongly hygroscopic, usually involute over the spore sac, covering it more or less entirely, with tips slightly revolute when wet. *Fleshy layer* adnate, continuous, not rimose or splitting, pecan brown to Vandyke brown. *Exterior* at first covered with a thin layer of mycelium and dirt, usually peeling off and leaving the outer surface of the fibrillose layer clean and free of dirt, usually dingy white. *Base* plane to convex when rays are expanded, not umbilicate. *Endoperidium* sessile, membranous, 8–15 mm. across, wood brown to light drab to benzo brown, minutely furfuraceous, soft to slightly asperate. *Mouth* usually concolorous with endoperidium, sulcate, acute, conic *sulci* of uneven length, usually branched at base, often wrinkled, 16–20 for long ones. *Gleba* seal brown. *Columella* subglobose to inevident.

Habitat: Solitary to usually gregarious in small groups in partial shade of desert or other vegetation.

Distribution: ARIZONA, near Prescott, 5500 ft., 1-2-34, *W. H. Long*, 2 plants, *7906;* 9-15-33, 1 plant, *7760;* Eagle Ranger District, Crook Nat. For., *D. J. Stouffer*, 3-24-47, 4 plants, *11455* and 3-28-47, 19 plants, *10104*. Prescott, 2-16-34, *W. H. Long & V. O. Sandberg*, 5 plants, *7615*. NEW MEXICO, Lincoln County, Jicarilla, 2-29-41, *D. J. Stouffer*, 11 plants, *9320;* 5-21-41, 23 plants, *9434;* 7-18-41, 10 plants, *9542;* Cougar Mt., August, '41, 25 plants, *9513;* Cougar Tank, 5-28-41, 22 plants, *9429;* Corona area, 9-6-41, *W. H. Long*, 12 plants, *9597;* 4-20-42, 24 plants, *10220;* 9-6-41, 18 plants, *9563;* Ranger Tank, 9-5-41, *W. H. Long & D. J. Stouffer*, 20 plants, *9529;* 9-15-41, 2 plants, *9663;* 5-19-40, *D. J. Stouffer*, 15 plants, *9430;* in sandhills near Gran Quivera Road, west of Corona, Sept. '41, 5 plants, *9844;* Corona area, 4-17-42, *W. H. Long*, 6 plants, *10072;* 8 mi. south of Oscuro, 2-17-42, *D. J. Stouffer*, 3 plants, *10020;* 4-18-42, *W. H. Long & D. J. Stouffer*, 16 plants, *10244;* Jornado Exp. Range, 9-8-41, *W. H. Long & D. J. Stouffer*, 4 plants, *9713;* 10-2-39, *W. H. Long*, 6 plants, *8399;* Corona area, 9-4-41, *W. H. Long & D. J. Stouffer*, 13 plants, *9508;* near Magdalena, Tres Montosas Mts., 10-11-34, *A. E. Frazier*, 6 plants, *8895;* Jornado Exp. Range, 9-7-41, *W. H. Long & D. J. Stouffer*, 3 plants, *9594;* Corona area, 4-15-42, *W. H. Long*, 4 plants, *11444*. TEXAS, Denton, 10-22-01, *W. H. Long*, 1 plant, *1081;* 12-20-02 (Long no. *7482*), 3 plants in Lloyd Myc. Coll. no. *22723*.

2. GEASTER PECTINATUS Pers. Syn. Meth. Fung., p. 132. 1801 (FIG. 2)

Sporophore hypogeous in leaf debris, with a universal mycelium, superficial at maturity, then revolute to vaulted. *Exoperidium* revolute, strongly vaulted, split about to the middle, 1–4 cm. across when expanded. *Rays* 10–12, pliable, not hygroscopic, very unequal, narrow, acute. *Fleshy layer* usually adnate, not rimose, wood brown to bister. *Exterior* covered with leaf debris. *Base* concave to often vaulted, no umbilical scar. *Endoperidium* pedicellate, pedicels slender, 2–3 mm. long, not striate, subglobose, 5–12 mm. wide by 8–12 mm. tall, with or without apophysis, lead or plum colored (dark plumbago slate) to Prout's brown, often with a white pruinose covering which easily rubs off, smooth. *Peristome* strongly sulcate, beaked or slender conical with 16–20 sulci, walnut brown, seated in a more or less definite depressed area. *Gleba* seal brown to blackish brown. *Columella* inevident. *Capillitium* light brown, unbranched, hyphae of capillitium 3–7 μ thick. *Spores* globose, brown, 4–6 μ in diameter. *Epispore* verrucose.

Habitat: In leaf debris of pines and junipers.

Distribution: ARIZONA, Eagle District, Crook Nat. For., 3-24-47, *D. J. Stouffer,* 2 plants, *11443.* NEW MEXICO, Corona area, Sept. '40, *D. J. Stouffer,* 2 plants, *9131;* 4-1-41, 5 plants, *9281;* 1-14-42, 1 plant, *9989;* 9-6-41, *W. H. Long,* 1 plant, *9813; W. H. Long & D. J. Stouffer,* 4-20-40, 4 plants, *9680;* 9-17-41, 1 plant, *9781;* 25 miles west of Corona, 12-15-41, *D. J. Stouffer,* 2 plants, *9964;* Lincoln County, Jicarilla, *9963;* 9-16-41, *W. H. Long & D. J. Stouffer,* 2 plants, *9793.*

3. GEASTER BRYANTII Berk. Outl. Brit. Fungi, p. 300. 1860 (FIG. 3)

Sporophore hypogeous in leaf debris with a universal mycelium, superficial at maturity, then becoming explanate to revolute. *Exoperidium* revolute to often involute, split to about the middle, 1.5–3 cm. across when expanded. *Rays* 8–12, pliable, not hydroscopic, very unequal, some involute at base of spore sac. *Fleshy layer* usually adnate, not rimose, wood brown to bister. *Exterior* covered with a thin layer of leaf debris, held by the mycelial layer. *Base* concave, often vaulted, no umbilical scar. *Endoperidium* pedicellate, pedicels slender, 1–3 mm. long, not striate, subglobose, 5–12 mm. wide by 5–10 mm. tall, with a well defined collar or ring around the base of the spore sac just above the top of the pedicel, lead to plum color (dark plumbeous slate) to light brown, usually with a pronounced white pruinose covering which easily rubs off.

Peristome strongly sulcate, beaked or slender conical, 12–16 sulci, 4–5 mm. tall, walnut brown, seated in a more or less depressed area. *Gleba* seal brown. *Columella* inevident. *Capillitium* brown, unbranched. *Spores* globose, 4–5.5 μ in diameter. *Epispore* distinctly verrucose.

Habitat: In leaf debris under junipers and mesquite trees.

Distribution: ARIZONA, 7 miles from Nogales, 2–19–34, *W. H. Long & V. O. Sandberg*, 9 plants, *7624*. NEW MEXICO, Corona area, 9–14–41, *W. H. Long & D. J. Stouffer*, 9 plants, *9665*. TEXAS, Denton, 12–23–07, *W. H. Long*, 2 plants, *2060;* 1901, ex Herb. C. L. Shear, 2 plants now in Lloyd Myc. Coll. no. *31143;* 10–22–01 (Long no. *1081*), 9 plants ex Herb. C. L. Shear; 1–12–03 (Long no. *1807*), 24 plants in Lloyd Myc. Coll. no. *51909*.

4. GEASTER SCHMIDELII Vitt. Mon. Lyc. p. 12. 1842 (FIG. 4)

Sporophore hypogeous in leaf debris with a universal mycelium, superficial and expanded at maturity. *Exoperidium* revolute, vaulted, split to about the middle, 1–2.5 cm. across when expanded. *Rays* 6–10, pliable, revolute, rarely involute under the spore sac, not hygroscopic, very unequal, many narrow, acute. *Fleshy layer* usually adnate, not rimose, wood brown when fresh becoming army brown to dingy white in age. *Exterior* covered with a dense layer of leaf debris. *Base* concave, often vaulted, no scar. *Endoperidium* subsessile to short pedicellate, pedicels stout, 1 mm. long or less, usually white, subglobose, 5–10 mm. wide by 6–12 mm. tall, apophysis none, wood brown to tilleul buff, rarely plumbeous black. *Peristome* strongly *sulcate*, short beaked or only slender conical, with 12–18 sulci, usually darker than exoperidium, seated in a more or less depressed area. *Gleba* seal brown. *Columella* inevident. *Capillitium* light brown, unbranched. *Spores* globose, medium dark, 4–5 μ in diameter. *Epispore* verruculose.

Habitat: In leaf debris under junipers.

Distribution: ARIZONA, Sabino Canyon area, near Tucson, 9–28–39, *W. H. Long*, 1 plant, *8774*. NEW MEXICO, Corona area, *D. J. Stouffer*, 4–4–40, 4 plants, *9266;* 5–19–41, 4 plants, *9446;* 6–16–41, 13 plants, *9435; W. H. Long & D. J. Stouffer*, 4–20–40, 8 plants, *8706;* 9–4–41, 1 plant, *10012;* 9–5–41, 1 plant, *9807;* 4–17–42, 20 plants, *10077;* Jornado Exp. Range, Sept. '41, 2 plants, *9591;* Cougar Tank, 5–28–40, *D. J. Stouffer*, 4 plants, *9445;* 20 mi. N.W. of Corona, 7–23–41, 3 plants, *9552*. TEXAS, Denton, *W. H. Long*, 1–12–13 (Long no. *1795*), 4 plants, Lloyd Myc. Coll. no. *51912;* 7–17–1900, 6 plants, *11199;* Shoal Creek, 7–17–1900, 2 plants, *11180;* Waller Creek, 3–2–03, *W. H. Long & A. M. Ferguson*, 3 plants, *11197* (Long no. *1816*); 1900–1901, 10 plants, Lloyd's no. *31571*.

This species as it grows in this area is smaller than either *G. pectinatus* or *G. Bryantii.*

5. GEASTER HARIOTII, Lloyd Myc. Writ. 2: 311. 1907 (FIG. 5)

Sporophore hypogeous, becoming superficial and expanded at maturity, then 2–3 cm. in diameter. *Exoperidium* explanate, split about two thirds of the way to middle. *Rays* 6–8 explanate, pliable, not hygroscopic, unequal, broad to narrow, acute. *Fleshy layer* adnate, not rimose or splitting off, snuff brown to Rood's brown. *Exterior* covered with a thin layer of soil (which is peeling off on one plant), cartridge buff on the naked under surface. *Base* plane to convex to slightly concave, no umbilical scar. *Exoperidium* sessile, subglobose, 6–12 mm. wide, no signs of pits, smooth, sayal brown to avellaneous. *Mouth* sulcate, slightly protruding, circular, acute. *Peristome* small with uneven sulci 20–30, sayal brown, darker than endoperidium. *Gleba* ferruginous. *Capillitium* hyaline to slightly tinted, walls very thin, 4.4–5.5 μ, outer wall rough, walls chestnut color. *Spores* globose, dark brown, 4–5 μ diameter. *Epispore* verrucose.

Habitat: In leaf debris under *Juniperus sabinoides.*

Distribution: TEXAS, Austin, 11–23–03, *A. M. Ferguson,* 3 plants, *11196.*

This is apparently a pale form of *G. Hariotii* Lloyd, and corresponds very closely to one of the plants in Lloyd's no. *52536,* which has 2 plants, one dark and typical and the other a much lighter color, collected by Gaudichaud in Rio de Janeiro, Brazil.

6. GEASTER ELEGANS Vitt. Mon. Lyc. p. 159, 1843 (FIG. 6)

Sporophore hypogeous, becoming superficial and expanded at maturity, 1–2 cm. across. *Exoperidium* revolute, vaulted, split to about the middle. *Rays* 6–11, subequal, acute, revolute, not hygroscopic, pliable. *Fleshy layer* adnate, not rimose, army brown. *Exterior* covered with a thin layer of dirt. *Base* concave, vaulted, no umbilical scar. *Endoperidium* sessile, sometimes subsaccate, 0.5–1 cm. across, smooth, with a soft furfuraceous reddish mat, brownish to dingy white after wintering, subglobose, seated in a slight depression. *Peristome* sulcate, protruding, dark brown, 6–8 equal sulci. *Gleba* cinnamon. *Columella* inevident. *Capillitium* light brown, thinner than the spores. *Spores* globose, 5–7 μ

diameter, uniguttulate. *Epispore* strongly verrucose, some appearing semireticulate.

Habitat: Gregarious in juniper and pine debris.

Distribution: ARIZONA, Flagstaff, in ponderosa pine duff, 2-6-34, *W. H. Long*, 3 plants, *10030*. NEW MEXICO, Corona area, 2-14-41, *D. J. Stouffer*, 10 plants, *9254;* near Ranger Tank, 5-12-41, 3 old plants, *9325*.

We compared these plants with *Geaster elegans* no. *51906* Lloyd Myc. Coll. from Alliers, France, collected by Rev. H. Bourdot, and found them to be the same. See Lloyd's plate 99, figures 5a and 5b.

7. **Geaster pluriosteus** sp. nov. (FIG. 7)

Sporophoro initio hypogaeo dein epigaeo. *Exoperidio* usque ad medium in 5–6 laciniis inaequalibus, acutis fisso, explanato vel recurvato, flaccido. *Endoperidio* 6–15 mm. lato, 5–8 mm. alto, globoso vel depresso-globoso, sessili, glabro. *Peristomio* plicati-sulcato, subconico, 6–15 mm. lato, 5–8 mm. alto. *Oribus* singulis usque pluribus, circularibus. *Sporis* globosis, verrucosis, 4–5 μ diam.

Sporophore hypogeous with a universal mycelium becoming superficial at maturity, then more or less explanate, 1.5–2 cm. across when fully expanded. *Exoperidium* explanate to slightly revolute, split one half to two thirds of the way to middle. *Rays* 5–6, pliable, not hygroscopic, very unequal, acute. *Fleshy layer* adnate, very thin when dry, not rimose or cracking, pecan brown. *Exterior* covered with a thin layer of sand. *Base* slightly concave, no umbilical scar. *Endoperidium* sessile, subglobose to depressed-globose, 6–15 mm. wide by 5–8 mm. tall, smooth, light drab when unweathered. *Mouth*, one to several, circular to elliptic, sulcate, short, acute, with 5–8 weak sulci, equal, extending to apex of peristome, drab to mouse gray, not in a depressed area, darker than balance of endoperidium. *Peristome* rather indeterminate, covered with close whitish granules which are not asperate and rub off rather easily in handling. *Gleba* cinnamon. *Columella* sepia. *Capillitium* colored, walls thin, about 5 μ thick. *Spores* globose, 5.5–7 μ diameter. *Epispore* coarsely verrucose.

Habitat: Gregarious in leaf debris of *Juniperus monosperma* but no leaf debris attached, only a thin layer of sand.

Distribution: NEW MEXICO, 5–6 miles N.E. of Corona, 9–17–41, *W. H. Long & D. J. Stouffer*, 6 plants, no. *9772;* Lincoln County, Jicarilla, 9–15–41, 1 plant, no. *9258*.

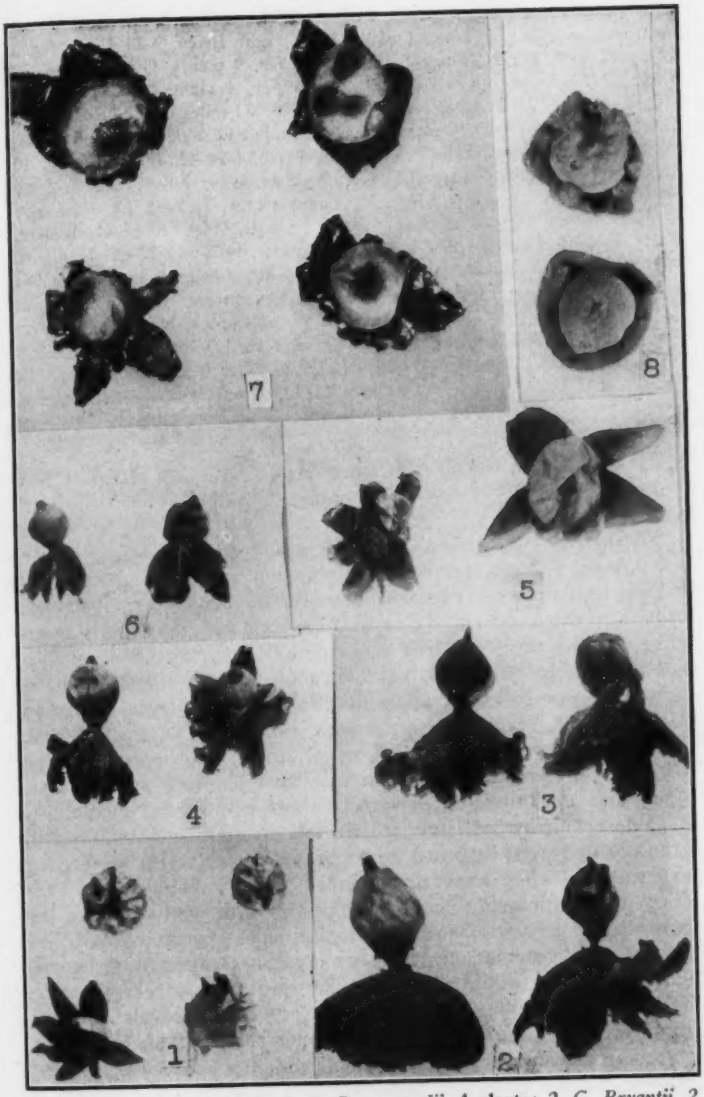
This is the only species of *Geaster* that we have ever seen with more than one mouth, although Cunningham (**1944**) reports a species—*G. ellipticis*, from Australia—that sometimes has two in the same fruiting body, but our plant apparently is a different species.

8. GEASTER XEROPHILUS Long, Mycologia **34**: 13–16. 1942 (FIG. 8)

Sporophore hypogeous, small, the button subglobose to strongly depressed-globose, or rarely concave on top, 1–2 cm. across, having a strong basal mycelial cord, becoming superficial and expanded at maturity, then 1–4 cm. in diameter, usual size about 2 cm. *Exoperidium* saccate to explanate, split to about the middle or rarely to center in old weathered plants. *Rays* 7–12, pliable not hygroscopic, unequal, blunt to truncate, tardily expanded or with tips involute around the spore sac. *Fleshy layer* cream buff to cinnamon, adnate, continuous, rarely rimose. *Exterior* covered with sand held by the persistent, thin, strongly adnate mycelial layer which even in very old weathered plants is still retained. *Base* concave with a prominent umbilical scar. *Endoperidium* subsessile to usually short-pedicellate, subglobose to strongly depressed-globose, often flattened on top (watch-shaped), 1–2 cm. across, light buff to drab gray when unweathered, becoming pallid mouse gray to pale cartridge buff (whitish) with age, densely and minutely furfuraceous (but not asperate), lower one third often enclosed by the saccate base of the exoperidium. *Peristome* small, usually circular, sometimes elliptic, acute, sulcate with 18–30 sulci of unequal thickness and length, some not extending to apex of peristome, not seated in a depressed area, concolorous or rarely darker, in age often becoming enlarged into a gaping mouth. *Gleba* mummy brown when not weathered but becoming snuff brown with age. *Columella* prominent, cylindrical, expanding at top into a persistent globose mass of hyphae. *Capillitium* simple, snuff brown, 4–4.5 μ thick. *Spores* globose, uniguttulate, 4–5 μ diameter, semiopaque in water. *Epispore* chestnut brown, coarsely verrucose.

Habitat: Solitary or in small groups, in open sandy area rarely in partial shade of desert plants; in hot dry regions.

Distribution: This is a continuation of the distribution given in the previous paper by Long (**1942**) but not included in it. NEW MEXICO, Jornado Exp. Range, 9–7–41, *W. H. Long & D. J. Stouffer*, 8 plants, *9593;* 9–8–41,



FIGS. 1–8, × 1. *Geaster;* 1, *G. Drummondii,* 4 plants; 2, *G. Bryantii,* 2 plants; 3, *G. pectinatus,* 2 plants; 4, *G. Schmidelii,* 2 plants; 5, *G. Hariotii,* 2 plants; 6, *G. elegans,* 2 plants; 7, *G. pluriosteus,* 4 plants; 8, *G. xerophilus,* 2 plants.

10 plants, *9713;* Oscuro, 4–18–42, 8 plants, *10243;* White Sands Nat. Monument, 8–22–42, *W. H. Long,* 1 plant, *10207;* near Belen, 9–24–41, 6 plants, *9725;* 12–6–41, *W. H. Long & D. J. Stouffer,* 9 plants, *9922;* 4–15–42, 2 plants, *10230;* Oscuro, 2–17–42, *D. J. Stouffer,* 4 plants, *10019;* 4–18–42, *W. H. Long & D. J. Stouffer,* 5 plants, *10090;* 34 miles east of Roswell, in Oak Shinnery, 4–19–42, 10 plants, *10089;* 10 miles west of Deming, 6 plants, *9830;* 9–13–41, 5 plants, *9657;* 4 plants, *9642;* 4–24–42, *W. H. Long,* 10 plants, *10066;* Bernalillo area, 8–24–41, 9 plants, *9470;* 9–8–41, *W. H. Long & D. J. Stouffer,* 6 plants, *9508;* Albuquerque area, 1–27–42, *W. H. Long;* 2 plants, *9988;* 8–23–41, 2 plants, *9466;* 2 plants, *9999;* 10–16–41, 1 plant, *9821;* 8–30–41, 19 plants, *9485;* 9–1–41, 9 plants, *9488;* 11–27–41, 11 plants, *9912;* 1–19–42, 20 plants, *9980;* 4–4–42, 2 plants, *10051;* 8–29–41, 10 miles south of Albuquerque, 4 plants, *9478;* Parida Canyon near Willard, 11–29–41, *D. J. Stouffer,* 1 plant, *9945;* 25 miles N.W. of Corona, 11–20–41, 9 plants, *9930;* 12–15–41, 2 plants, *9962;* Gran Quivera road, west of Corona, Sept. '41, 1 plant, *9842;* in sand-hill-juniper area 25 miles from Corona, 9–17–41, *W. H. Long & D. J. Stouffer,* 4 plants, *9741;* Corona area, 9–4–41, 3 plants, *9498;* Oct. '41, *D. J. Stouffer,* 8 plants, *9866.*

9. GEASTER CAMPESTRIS Morgan, Am. Nat. 21: 1026. 1887 (FIG. 9)

Sporophore hypogeous with universal mycelium, small, button subglobose, 1–2 cm. across, some showing an umbilical scar, becoming superficial and expanded at maturity, then 1–3 cm. diameter, usual size about 2.5 cm. *Exoperidium* explanate to slightly revolute, split about two thirds way to middle. *Rays* 5–8, pliable, *not* hygroscopic, unequal, narrow, acute. *Fleshy layer* adnate, not rimose or splitting off from middle fibrous layer, bister to Mars brown. *Exterior* covered with a thin layer of blackish soil, held by the persistent, adnate mycelial layer. *Base* concave, some with a small umbilical scar but most not showing such a scar. *Endoperidium* subsessile to usually short pedicellate, subglobose, 6–15 mm. wide by 5–10 mm. tall, densely covered with small brown granules or warts, asperate, wood brown under warts, dark gray to light drab when warts are included, easily rubbing off in handling, warts appearing like dark stippling with whitish bloom between them. *Peristome* small, circular, sulcate, acute, with 10–14 sulci of equal thickness and length, extending to apex of peristome, dark brown, seated in a definite depressed area, darker than the balance of the endoperidium, sepia color. *Gleba* sayal brown to snuff brown. *Columella* prominent, persistent in mature plant, globose. *Capillitium* simple, hyaline, solid, 2.8–4.2 μ thick. *Spores* globose, 5.6–6 μ diameter, usual size 5–6, uniguttulate, contents of spore tinted brown, semi-opaque in water. *Epispore* chestnut brown, verrucose.

Habitat: Gregarious in earth by sidewalk in city of Lincoln, Neb., or in open grassy prairies about Lincoln. Sept. 27, 1886.

Distribution: Vicinity of Lincoln, Neb., Sept. 27, 1886, *C. E. Bessey,* usually in open prairie.

The above is from type material. I soaked three plants for three hours in water without the least signs of any extension of the rays, so they cannot be called hygroscopic. The rays soften some but do not change in position. All three plants showed brown warts, which are rough or asperate when dry.

The type of *Geaster campestris* is from the open grassy prairies in the vicinity of Lincoln, Neb., hence its name, but all of our material from the Southwest is from shade or partial shade of desert vegetation and varies in many minor details from the type plants. The type is not at all hygroscopic, whereas our plants are more or less hygroscopic. The sizes, colors, stipes etc. vary much from the type and often from each other yet in spite of these differences we have included all these forms under the name *G. campestris,* since they intergrade so much that no fixed definite line of demarcation can be found. We are giving herewith for comparison the type description, the combined description from all our plants and the description from the Nogales specimens since they vary more than any others from the usual run of our material of this species. The Nogales plants differ more than any others and may deserve a varietal name but we doubt it, believing that the dry semi-arid environment of our climate here may have caused these changes from the type.

GEASTER CAMPESTRIS composite description from all collections (FIG. 10)

Sporophore hypogeous with a universal mycelium, button small, subglobose, 1–2 cm. across, some showing an umbilical scar and some not, becoming superficial and more or less explanate at maturity, 1–4 cm. diameter when expanded, usual size about 2.5 cm. *Exoperidium* explanate, revolute or involute under (rarely over) the spore sac, split one half to two thirds of the way to middle.

Rays 5–12, acute, subequal, pliable to rigid, often subhygroscopic. *Fleshy layer* adnate, continuous, not rimose or cracking, bister, Mars brown to benzo drab. *Exterior* covered with dirt or

leaf debris, rarely peeling off and leaving the outer surface of the rigid fibrillose layer, naked. *Base* concave, sometimes with a small umbilical scar, but most of them not showing this scar. *Endoperidium* subsessile to short pedicellate, apophysis often present, subglobose, 6–18 mm. wide, covered with small, rough or asperate granules or warts seen only with a good hand lens but evident to the touch, wood brown, general color dark gray to light drab; often the granules rub off in handling. *Peristome* small, circular, sulcate, acute, with 10–20 sulci of equal thickness and length, extending to apex of peristome, light drab to dark brown, many seated in a depressed area but often not, usually darker than the endoperidium but often concolorous with it. *Gleba* sayal brown to chocolate brown to blackish brown. *Columella* globose, usually persistent in mature plants. *Capillitium* simple, hyaline, with thin or thick walls, threads 3–4 μ thick. *Spores* globose, 4.2–7 μ diameter, semi-opaque in water. *Epispore* subhyaline to chestnut brown, verrucose.

Habitat: Gregarious in this region in leaf debris under or at the edge of conifers and hardwood trees, rarely in open soil.

Distribution: ARIZONA, Flagstaff, 2-6-34, *W. H. Long;* 6 plants, *8979;* Sabino Canyon area near Tucson, 6-4-35, 11 plants, *8769;* Prescott, Peterson area, 99 plants, *7687; W. H. Long & V. O. Sandberg* 4-34, 84 plants, *7689;* 7 miles of Nogales, 2-19-34, 4 plants, *4867;* 9-11-41, *W. H. Long & D. J. Stouffer,* 38 plants, *9629;* 49 plants, *9635.* Eagle District, Crook Nat. For., *D. J. Stouffer,* 3-26-47, 2 plants, *7863.* NEW MEXICO, Jemez Mts., *Ernest Knaebel,* 31 plants in Lloyd Myc. Coll. no. *52512;* Eureka Lodge near Cuba, 8300 ft. elevation, *W. H. Long,* 37 plants, *7770;* 9-13-33, 5 plants, *7767;* 5-21-33, 19 plants, *8977;* 8-13-39, 1 plant, *9069;* 9-25-37, 11 plants, *9884;* near Dulce, Stone Lake, 7600 ft., 6-25-34, *Ledru Savage & R. L. Turner,* 11 plants, *8022;* Tres Montosas Mts. area near Magdalena, 10-11-34, *A. E. Frazier,* 3 plants, *7988;* sandhill-juniper area 25 miles from Corona, *D. J. Stouffer,* 11-27-41, 2 plants, *9932;* 12-15-41, 17 plants, *9963;* 4-21-42, 9 plants, *10206;* and 5 plants, *10201;* 9-17-41, *W. H. Long & D. J. Stouffer,* 16 plants, *9740;* Jicarilla, Lincoln County, 9-6-41, 4 plants, *9760;* 9-16-41, 1 plant, *10028;* 5-21-41, 6 plants, *9449;* 20 miles N.W. Corona, 5-8-41, *D. J. Stouffer,* 8 plants, *9318;* Cougar Mt. area, 4-21-40, *W. H. Long & D. J. Stouffer,* 7 plants, *8693;* near Cougar Tank, 5-12-41, *D. J. Stouffer,* 2 plants, *9823;* near Ranger Tank, 5-12-41, *D. J. Stouffer,* 4 plants, *9324;* 9-15-41, *W. H. Long & D. J. Stouffer,* 1 plant, *9808;* Corona area, *D. J. Stouffer,* 5-2-39, 20 plants, *8370;* July, '40, 2 plants, *8708;* Oct. '40, 3 plants, *9169;* 4-4-41, 19 plants, *9267;* 4-20-41, 3 plants, *9321;* 4-1-41, 2 plants, *9269;* April, '41, *W. H. Long & D. J. Stouffer,* 5 plants, *9510;* 4-20-40, 10 plants, *9143;* 9-6-41, 5 plants, *8566;* 9-15-41, 10 plants, *9751;* and 7 plants, *9728;* 9-17-41, 9 plants, *9773;* 4-17-42, 8 plants, *10068;* April, '42, 4 plants, *10059.* TEXAS, Denton, 12-23-07, *W. H. Long,* 2 plants, *2059;* 7-12-03 (Long no. *1793*), 15 plants in Lloyd Myc. Coll. no. *52514.*

The collections from Eureka Lodge, and Dulce, New Mexico, and from the Peterson area near Prescott, Arizona, all high altitude localities, had numerous sessile to subsessile plants, making them approach *Geaster Drummondii;* also in some cases the plants had shed all of the outer mycelial layer and some were strongly hygroscopic, again making them resemble *G. Drummondii,* but other plants with these were typical *G. campestris.*

GEASTER CAMPESTRIS var. ? (FIG. 11)

Sporophore hypogeous with a universal mycelium; buttons small, subglobose, 6–10 mm. across, all showing an umbilical scar on base, becoming superficial at maturity, then a few are explanate but most of them not so, involute under base of spore sac, 5–30 mm. across, usual size 1–1.5 cm. when fully expanded. *Exoperidium* mostly involute around base of spore sac, a few revolute, split about half way to middle. *Rays* 6–10 rigid, subhygroscopic, unequal, acute. *Fleshy layer* adnate, continuous, not rimose when not weathered, minutely warty, then a stippled cinnamon drab to benzo drab, with age becoming smooth and chaetura black. *Exterior* covered with a layer of hyphae and leaf debris, held by the persistent mycelial layer. *Base* concave, with or without an umbilical scar. *Endoperidium* subsessile to usually short pedicellate, subglobose, 5–10 mm. wide by 5–12 mm. tall, usually with a distinct apophysis, densely covered with brownish rough granules or warts, light drab under warts, giving the surface a grayish stippled look. *Peristome* small, circular, sulcate, acute, with 12–16 sulci of equal thickness and length, extending to apex of peristome, some light drab but most of them hair brown to chaetura black, seated in a definite area darker than the balance of the endoperidium. *Gleba* mummy brown to blackish brown. *Columella* inevident or in some oblong to subglobose and persistent. *Capillitium* colored, fulvous, walls thin, 3–4 μ. *Spores* globose, verrucose, 5.6–7 μ diameter, opaque in water, uniguttulate. *Epispore* coarsely verrucose, wall subhyaline to chestnut brown.

Habitat: Gregarious in debris under catclaw and mesquite trees, in hot dry regions.

Distribution: On highway U. S. no. 89 from Nogales to Tucson.

10. GEASTER SMITHII Lloyd, Myc. Writ. 1: Geastrae, pp. 21 and 42. 1902 (FIG. 12)

Sporophore hypogeous in leaf debris, becoming superficial and expanded at maturity, then 1.5–4 cm. across. *Exoperidium* revolute, splitting to about the middle, often vaulted. *Rays* 7–13, subequal, acute, some splitting again at the tips, usually not hygroscopic but some plants slightly subhygroscopic, and involute under the spore sac, when dry. *Fleshy layer* thin, adnate, often rimose and peeling, lead color to ferruginous, farinose when fresh. *Exterior* covered with leaf debris by adnate mycelial layer which often peels off at the tips, these rays then becoming involute, exposed under side of the naked rays light tan. *Base* concave, rarely umbilicate. *Endoperidium* short pedicelled, subglobose to pyriform to urceolate, 5–18 mm. across, usually chestnut brown but one collection from Arizona pallid tan, papyraceous. *Peristome* flattened-conical, seated in a very definite depressed area, concolorous or often darker than the endoperidium, regularly sulcate-striate, sulci unequal, 20–30, many sulci short and not reaching top of peristome. *Gleba* chestnut brown to blackish brown. *Columella* inevident. *Capillitium* subhyaline to fulvous, thinner than the spores. *Spores* dark fuliginous, almost opaque, globose, 4–5 μ diameter. *Epispore* verruculose.

Habitat: Gregarious in leaf debris usually under *Juniperus monosperma.*

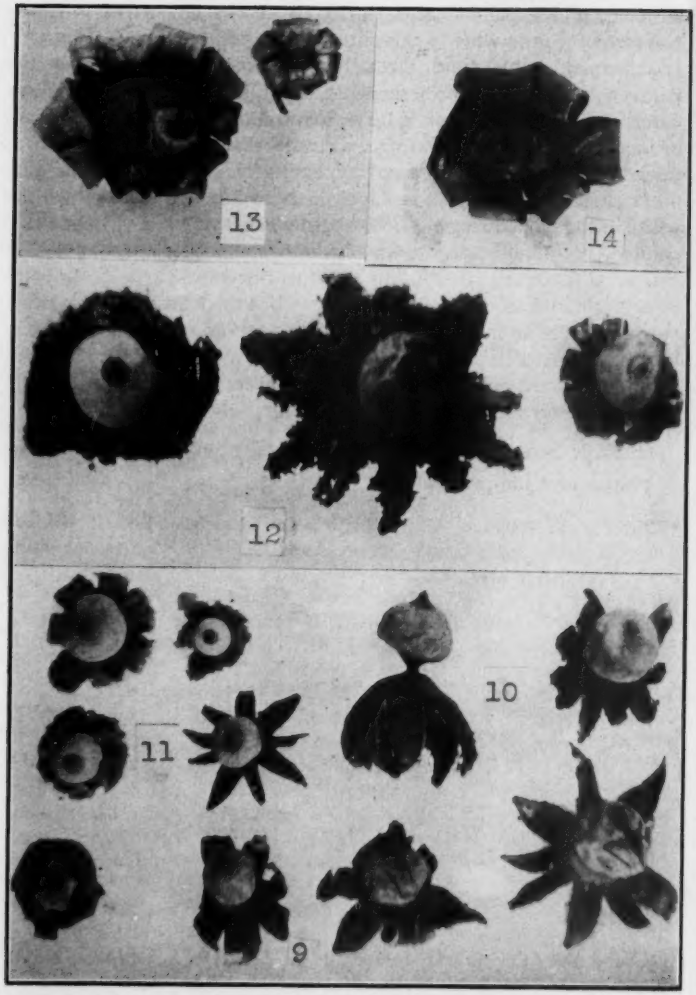
Distribution: ARIZONA, Sabino Canyon area, 9–28–39, *W. H. Long,* 1 plant, *9144;* Safford, 9–9–40, *W. H. Long & D. J. Stouffer,* 1 plant, *10024;* 9–9–41, 4 plants, *9706;* near Young in Tonto Nat. For., August, '44, *N. F. Noecker & L. W. Robeson,* 8 plants, *7970.* NEW MEXICO, Corona area, 4–17–42, *W. H. Long & D. J. Stouffer,* 61 plants, *10069;* near Atkinson Ranch, 9–21–42, 46 plants, *10116;* Tres Montosas Mts. near Magdalena, 10–11–34, *A. E. Frazier,* 1 plant, *8892;* Corona area, 9–4–41, *W. H. Long & D. J. Stouffer,* 24 plants, *9505;* 9–14–41, *W. H. Long & D. J. Stouffer,* 8 plants, *9764;* 2–19–40, *D. J. Stouffer,* 2 plants, *9286;* 4–6–43, 2 plants, *10357;* 25 miles N.W. of Corona, 4–20–40, 2 plants, *9287;* 1–14–42, 83 plants, *9993;* 9–17–41, *W. H. Long & D. J. Stouffer,* 91 plants, *9777;* Corona area, 7000 feet elevation, 2–28–40, *D. J. Stouffer,* 2 plants, *8476;* 4–4–41, 11 plants, *9265;* Oct. '41, 20 plants, *9861,* in sand hills along Gran Quivera road, Sept. '41, 7 plants, *9843;* Oct. '41, 16 plants, *9865;* April, '40, *W. H. Long & D. J. Stouffer,* 10 plants, *9096;* July, '40, 13 plants, *8724;* 4–1–40, 15 plants, *8726;* 9–15–41, 19 plants, *9662;* near Ranger Tank, 9–5–41, 4 plants, *9802;* sandhill-juniper dunes about 20 miles from Corona, 9–17–41, 4 plants, *9738;* Cedarvale area, Pinos Mts., Nov. '40, *D. J. Stouffer,* 7 plants, *9216;* Atkinson sandhill pasture, 25 miles from Corona, 12–15–41, 4 plants, *9966.*

11. GEASTER MAMMOSUS (Chev.) Fr. Syst. Myc. 3: 17. 1829 (FIG. 13)

Sporophore hypogeous with a universal mycelium, becoming superficial, and expanded at maturity, then 1–4 cm. across. *Exoperidium* revolute when wet, splitting nearly to the base. *Rays* 8–12, unequal, acute, rigid, strongly hygroscopic, more or less involute over the entire spore sac when dry, dirty white to light brown externally. *Fleshy layer* adnate, continuous, not rimose, clove brown to chaetura black in age. *Exterior* at first covered with a thick mycelial layer of dirt and hyphae, deciduous and leaving the outer surface of the fibrillose layer clean of dirt and a dingy white, white in the button stage. *Base* slightly concave when rays are expanded, not umbilicate. *Endoperidium* subglobose, sessile, 1–1.5 cm. across, Rood's brown, slightly furfuraceous, partially smooth in age, globose to depressed-globose. *Mouth* definite with a silky peristome, conic, mouth parts usually a darker color than balance of the peristome. *Gleba* blackish brown to chaetura black. *Columella* short, cylindrical, pointed. *Spores* globose, light brown, 3–5 μ diameter. *Epispore* brownish, minutely verrucose.

Habitat: Solitary or gregarious in small groups in partial shade of piñons and junipers.

Distribution: ARIZONA, V. T. Ranch near old airfield, 8800 ft., *W. H. Long*, 10 plants, *7841;* Grand Canyon, Aug. '34, *Dr. R. B. Street*, 1 plant, *8968;* Blue River area, Eagle District, Crook Nat. For., 3-24-47, *D. J. Stouffer*, 13 plants, *11445.* NEW MEXICO, Corona area, 7000 ft., 4–16–42, *W. H. Long*, 7 plants, *10058;* 4–17–42, 11 plants, *10078;* 9–6–41, 16 plants, *9568;* 4–14–42, 38 plants, *10236;* 9–15–41, 3 plants, *9726;* Sept. '40, *D. J. Stouffer*, 8 plants, *9130;* 11–7–40, 6 plants, *9212;* 5–25–41, 8 plants, *9432;* 7–5–41, *Jack Porter*, 11 buttons, *9366;* 7–16–41, 11 plants, *9539;* 9–17–41, *W. H. Long & D. J. Stouffer*, 56 plants, *9780;* 9–15–41, 13 plants, *9752;* 9–17–41, 18 plants, *9742* and 14 plants, *9660;* 9–14–41, 75 plants, *9768;* 4–21–42, 37 plants, *10119;* Atkinson Ranch, 25 miles from Corona, 12–15–41, *D. J. Stouffer*, 3 plants, *9965;* near Cougar Tank, 5–28–41, 5 plants, *9424;* near Mulkey Ranch, 20 miles N.W. of Corona, April, '41, 13 plants, *9319;* Parida Canyon near Willard, 11–11–40, 1 plant, *9202;* 11–29–40, 1 plant, *9202;* 11–29–41, 11 plants, *9938;* near Vaughn, 6–15–41, 5 plants, *9419;* Lincoln County, Jicarilla, 9–16–41, *W. H. Long & D. J. Stouffer*, 48 plants, *9761;* Deming, 10 miles west, 9–9–41, 1 plant, *9832;* Tres Ritas, Amole Canyon, 8200 ft., Oct. '10, *W. H. Long*, 45 plants, *8864;* La Junta Canyon, Oct. '14, 14 plants, *8863;* and 12 plants, *5242;* Corona area, 4–20–42, *W. H. Long*, 110 plants, *10219;* 9–6–41, 10 plants, *11441;* 4–21–40, *W. H. Long & D. J. Stouffer*, 142 plants, *8737;* 4–21–40, *W. H. Long & D. J. Stouffer*, 32 plants, *7829;* *D. J. Stouffer*, 2–28–40, 27 plants, *8481;* near Cougar Mt., 7100 ft., May, '40, 13 plants, *8825;* 4–21–40, *W. H. Long & D. J. Stouffer*, 27 plants, *8734;* Oct. '40, *D. J. Stouffer*, 21 plants, *9173;* 4–20–40, *W. H. Long & D. J. Stouffer*, 13 plants, *8702.* TEXAS, Denton, *W. H. Long*, 12–23–07, 15 plants, *2028.*



FIGS. 9–14, × 1. *Geaster;* 9, *G. campestris* from type material, 4 plants; 10, *G. campestris* usual form, 2 plants; 11, *G. campestris,* form near Nogales, 4 plants; 12, *G. Smithii,* 3 plants; 13, *G. mammosus,* 2 plants; 14, *G. xylogenus,* 1 plant.

12. **Geaster xylogenus** sp. nov. (FIG. 14)

Sporophoro lignicolo. *Exoperidio* revoluto, coriaceo, subhygrometrico, usque ad centrum in 8 laciniis, involutis, acuminatis fisso. *Endoperidio* stipitato, toto evanescenti. *Stipite* crasso, subligneo, 5 mm. crasso, 10 mm. lato, 2 mm. alto. *Capillitio* subhyalino vel fusco, 5–6 μ lato, simplici. *Sporis* globosis, 3.2–5 μ diametro, verrucosis.

Sporophore epigeous, buttons not found but apparently they were acute, judging from the acuminate tips of the exoperidium, becoming expanded at maturity. *Exoperidium* revolute, rigid, coriaceous, subhygroscopic, splitting nearly three fourths the way to the center into 8 segments, deeply concave below, dome-shaped above. *Rays* unequal, recurved, with strongly involute acuminate curled tips, 4–5 cm. long, faintly longitudinally striate. *Exterior* naked, smooth, pecan brown. *Fleshy layer* adnate but peeling off above, chestnut brown, thin. *Endoperidium* short stipitate, deciduous (only fragments left), brittle, breaking away at base, Mars brown. *Sterile base* none. *Stipe* stout, subligneous, 5 mm. thick by 10 mm. wide by 2 mm. tall. *Gleba* liver brown, but little remaining. *Columella* inevident. *Capillitium* subhyaline to light fuliginous, thicker than spores, 5–6 μ thick, unbranched. *Spores* globose, 3.2–5 μ, usual size 4.2 μ. *Epispore* dark brown, verrucose.

Habitat: Solitary, growing on an old rotting, prostrate pine log (*Pinus ponderosa*) in shade of Gambel oak (*Quercus gambelii*).

Distribution: NEW MEXICO, Sandoval County in lower part of Senorito Canyon about 6 miles from Cuba, elevation 6400 ft., *W. H. Long*, 9-26-37, no. *11028* **Type** (1 plant).

This plant is peculiar in that it has a deciduous endoperidium similar to the genus *Terrostella* but does not have the sterile base of that genus, nor does it have the persistent subligneous columella of a *Trichaster*. We are therefore leaving it under the genus *Geaster*.

13. GEASTER ARENARIUS Lloyd, Myc. Writ. 1: Geastrae 28. 1902 (FIG. 17)

Sporophore hypogeous in leaf debris and soil, becoming superficial and expanded at maturity, then 1.5–2.5 cm. across. *Exoperidium* rarely explanate or revolute, usually involute around base of spore sac, splitting nearly to middle or only to middle. *Rays* 8–12, very unequal, some explanate to revolute but mostly involute around the spore sac, weakly subhygroscopic, thin, acute. *Fleshy layer* thin, adnate, not rimose, clay color to sayal brown. *Exterior*

covered with leaf debris and dirt, not peeling off. *Endoperidium* globose to subglobose, pallid mouse gray to dingy white, sessile to subsessile, rarely with a short pedicel, very thin, brittle and papyraceous. *Peristome* very definite in a depression, much darker than the endoperidium, deep mouse gray to dark mouse gray, conic, often fibrillose. *Gleba* seal brown. *Columella* globose. *Capillitium* light brown, walls thin, lumen large, with brown walls, 3–4 μ thick. *Spores* globose, 3.5–4.2 μ in diameter. *Epispore* verruculose.

Habitat: Gregarious in leaf debris under mesquite and catclaw.

Distribution: ARIZONA, Sabino Canyon area, 2–20–34, *W. H. Long & V. O. Sandberg,* 6 plants, *7609;* 11–11–36, 4 plants, *8897;* 6–4–38, *W. H. Long,* 49 plants, *8314;* 11–10–38, 12 plants, *8256;* 6–21–38, 77 plants, *9263;* 9–28–39, 23 plants, *8392;* 7 miles from Nogales on highway 84, 11–23–33, *W. H. Long & V. O. Sandberg,* 1 plant, *7853;* 2–29–34, 21 plants, *8768;* 11–13–36, 23 plants, *8846;* 6–4–38, 31 plants, *8304;* 9–11–41, *W. H. Long & D. J. Stouffer,* 55 plants, *9627;* and 81 plants, *9634;* 63 plants, *9696;* Mt. Mingus, Prescott Nat. For., 5–18–34, *W. H. Long,* 2 plants, *8813.* NEW MEXICO, Jornado Exp. Range, 9–8–41, *W. H. Long & D. J. Stouffer,* 1 plant, *9708;* 10 miles west of Deming, *W. H. Long,* 4–24–42, 9 plants, *10062.* TEXAS, Denton, 1–10–03, *W. H. Long,* no. *1788,* 16 plants, Lloyd Myc. Coll. no. *52513,* as *Geaster asper.* This collection is very much like the plants collected 7 miles from Nogales, Arizona.

14. GEASTER TOMENTOSUS Lloyd, Myc. Writ. **5**: 818. 1919 (FIG. 18)

Sporophore epigeous with fibrillose basal mycelium, more or less expanded at maturity, then 1.5 cm. across, buttons subglobose. *Exoperidium* flaccid, more or less revolute, opening about one half to center, leaving the base strongly saccate. *Rays* subequal, 6–8, acute, not hygroscopic. *Fleshy layer* pecan brown, adnate, not rimose or flaking off. *Exterior* covered with a matted tomentum, persistent unless worn away by age or handling, light pinkish cinnamon. *Endoperidium* subglobose, sessile, saccate, light drab, about 1 cm. in diameter, with a prominent peristome. *Peristome* circular with a border, fibrillose, about 5 mm. in diameter, darker than the endoperidium, mouse gray, of different texture than the surrounding tissue. *Mouth* subconical. *Gleba* blackish brown to black. *Columella* slender, linear. *Capillitium* brown, not branched. *Spores* globose, dusky brown, semi-opaque, 4.2–4.5 μ. *Epispore* verrucose.

Habitat: Gregarious to cespitose, on ground in open pine woods.

Distribution: TEXAS, Houston, *George L. Fisher,* no. *26,* 10–30–18, 7 plants including 5 buttons in Lloyd Myc. Coll. no. *54721* **Type**; in woodland pasture, *George L. Fisher,* no. *28,* 10–30–18, 2 buttons in Lloyd Myc. Coll. no. *4800;* on ground (Fisher no. *19*), 3 buttons, in Lloyd Myc. Coll. no. *54720.*

The opened plants resemble very much a small form of *Geaster saccatus* as noted by Lloyd (**1919**) whereas the buttons with their fibrillose basal roots are much like an unopened *Lycoperdon.* This species has not been reported since the above records as far as we know.

15. GEASTER MINIMUS Schw. Syn. Fung. Car. p. 58, n. 327. 1822
(FIGS. 15–16)

Sporophore hypogeous in leaf debris with universal mycelium, becoming superficial and expanded at maturity, then 1–4 cm. *Exoperidium* revolute, split to about the middle. *Rays* 8–12, subequal, acute, often recurved till they are more or less vertical, tips occasionally involute around edge of dome. *Fleshy layer* adnate, rarely cracking, Mikado brown to light pinkish cinnamon. *Exterior* covered with debris, shaggy from the adhering fragments, persistent. *Base* concave to vaulted, not umbilicate. *Endoperidium* pedicellate, pedicel short, subglobose to ovate to often elongated pear-shaped, 3–10 mm. diameter. *Mouth* definite, grooved, with a silky peristome, usually seated in a depression bordered by a ring, peristome lighter or darker or concolorous with endoperidium. *Gleba* seal brown. *Columella* subglobose. *Capillitium* hyaline. *Spores* globose, 5.4–5.5 μ in diameter. *Epispore* slightly verruculose but some appearing smooth even under oil immersion lens.

Habitat: Gregarious under conifers and hardwoods in the leaf debris.

Distribution: ARIZONA, Sabino Canyon area near Tucson, 6–4–38, *W. H. Long,* 49 plants, *8314;* Young in Tonto Nat. For., August, '38, *N. L. Noecker & L. W. Robeson,* 15 plants, *8906;* Safford, 9–9–41, *W. H. Long & D. J. Stouffer,* 2 plants, *2703;* Grand Canyon, Arizona, 1930, Dr. R. B. Street, 3 plants, *7889;* Flagstaff and vicinity, 8300 feet, 7–4–36, *W. H. Long,* 1 plant, *9374;* 9 plants, *7802;* 4 plants, *7695;* 12 miles from Flagstaff, 5–2–33, 6 plants, *8869.* NEW MEXICO, Corona area, 4–20–40, *W. H. Long & D. J. Stouffer,* 230 plants, *8705;* 4–15–42, 11 plants, *10234;* 4–21–40, 8 plants, *8740;* September, '40, *D. J. Stouffer,* 5 plants, *9126;* 9–17–41, *W. H. Long & D. J. Stouffer,* 2 plants, *10008;* 20 miles N.W. Corona, 1–2–41, *D. J. Stouffer,* 6 plants, *9247;* 7–23–41, 2 plants, *9553;* Lincoln County, Jicarilla, 5–6–41, 27 plants, *9315;* 4–1–41, *D. J. Stouffer,* 6 plants, *9270;* 5–19–41, 3 plants, *9447;* 2–14–40, 14 plants, *9251;* 9–4–41, *W. H. Long & D. J. Stouffer,* 6 plants, *9504;* 9–17–41, 5 plants, *9738;* 5 plants, *9774;* 9–18–41,

8 plants, *9750;* 4–16–42, 5 plants, *10209;* 4–17–42, 28 plants, *10076;* Atkinson Ranch, 4–21–42, 33 plants, *10203;* Ranger Tank, *D. J. Stouffer,* 9–5–41, 17 plants, *9528;* Cougar Tank, 10 plants, *9397;* Corona area, 1–24–41, 12 plants, *9255;* Mulkey Ranch, 11–7–40, 43 plants, *9251;* Jicarilla, Lincoln County, 2–15–41, 1 plant, *9257;* 7–18–41, 2 plants, *9544;* 9–16–42, *W. H. Long & D. J. Stouffer,* 31 plants, *9759;* Red Cloud Picnic Grounds, 4–16–42, 1 plant, *10242;* 40 plants, *10228;* Jicarilla, Lincoln County, 9–15–41, 34 plants, *9671;* Willard in Parida Canyon, 11–29–41, *D. J. Stouffer,* 5 plants, *9943;* Tres Montosas Mt. area near Magdalena, 10–16–34, *A. E. Frazier,* 17 plants, *8890;* White Sands National Monument, 4–12–42, *W. H. Long,* 1 plant, *10115;* Pecos, 11–25–12, 67 plants, *8862;* 1916, 6 plants, *8865.* TEXAS, Denton, Dec. '02, *W. H. Long,* no. *1785,* 4 plants, Lloyd Myc. Coll. no. *23009;* 12–23–07 (Long no. *2051*), 2 plants, Lloyd Myc. Coll. no. *23022;* 10–10–07, *W. H. Long,* 2 plants, *2029;* 12–23–07, 4 plants, *2051.*

A comparison was made with the type material of *Geaster juniperinus* and it was found that this species is only a larger and darker form of *G. minimus* and not a form of *G. coronatus* as suggested by some writers. Also we do not believe that *G. coronatus* is a synonym of *G. minimus.* Johnson (**1929**) makes very clear the differences between the two species and her reasons for not combining them seem valid. The assumption that certain plants belong to the same species because they have been found growing from the same mycelial mat is not proof that they are the same. We have found *G. Smithii* and *G. fornicatus,* side by side from the same mycelial substratum, and yet no one could claim they are the same species.

16. GEASTER CORONATUS (Schaeff.) Schroet. Pilze Schles. p. 702. 1889 (FIG. 19)

Sporophore hypogeous in leaf debris with a universal mycelium, becoming superficial and fornicate at maturity, then 1–1.5 cm. across at base. *Exoperidium* revolute, bending strongly backward and downward, usually splitting to beyond the middle. *Rays* 4–5, broad, subequal, tips attached to the fornicate mycelial layer, not hygroscopic, but rigid. *Fleshy layer* Vandyke brown to burnt umber in age, then shining and peeling off and leaving a naked surface light buff to dingy white. *Exterior* mycelial layer is stripped off from the fibrous layer when evagination occurs and remains as a more or less hollow cup attached to the tips of the rays. *Endoperidium* pedicellate, ovate to oblong, attenuate at base, with a prominent apophysis, plum colored (bone brown), 5–10 mm. broad by 8–12 mm. tall. *Mouth* definite, prominently raised,

seated in a depressed area with a definite silky zone, bounded by a ridge. *Peristome* markedly lighter in color than the endoperidium, sayal brown. *Gleba* seal brown. *Columella* slender or inevident. *Capillitium* pale brown, 2–5 μ thick, rarely branched. *Spores* globose, 4–4.5 μ in diameter. *Epispore* distinctly warted.

Habitat: Gregarious in leaf debris in a mixed stand of cork-bark fir (*Abies arizonica*), Douglas fir (*Pseudotsuga taxifolia*) and aspen (*Populus tremuloides*) at an elevation of 9000 feet.

Distribution: ARIZONA, Mt. Graham in Crook Nat. For., 5–8–47, *D. J. Stouffer,* 30 plants, *11458.*

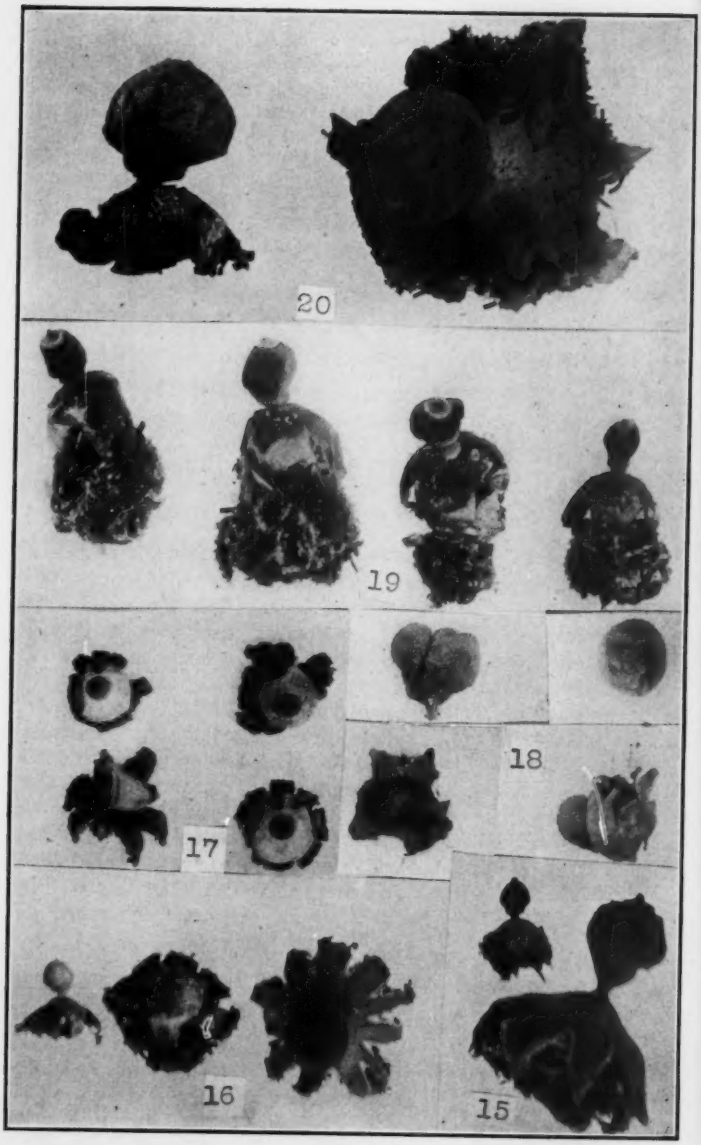
These plants apparently are smaller than normal. The spore sacs and peristomes are very uniform in color and the fleshy layer usually peels off in weathering. This is the first time this beautiful little species has been found in our territory.

17. GEASTER HIERONYMI Henn. Hedw. **36**: 211. 1897 (FIG. 20)

Sporophore hypogeous in leaf debris, becoming superficial and expanding at maturity, then 3–7 cm. across; buttons globose. *Exoperidium* revolute, often involute, usually splitting to about the middle. *Rays* 6–8, rarely 10, revolute or sometimes partially involute beneath the spore sac, acute. *Fleshy layer* bay brown or darker, thin, adnate, often peeling off and leaving the fibrous layer chestnut brown. *Exterior* covered with debris. *Base* concave, not umbilicate. *Endoperidium* short pedicellate, the stalk often strongly flattened with a prominent apophysis, depressed-globose, obovate to urceolate, harshly asperate with prominent black spicules, dark brown to grey-brown to silvery brown, much like the spore sac of a *Myriostoma,* 1.5–3 cm. across. *Mouth* indefinite, naked, short, slightly conical, often fimbriate with age. *Gleba* sepia. *Columella* large, globose to conical. *Capillitium* light brown, 3–5 μ thick. *Spores* 2.9–4.5 μ diameter. *Epispore* minutely verruculose.

Habitat: Gregarious in leaf debris of *Juniperus monosperma.*

Distribution: NEW MEXICO, Corona area, 4-17-42, *W. H. Long & D. J. Stouffer,* 32 plants, *10071;* 9-17-41, 1 plant, *10006;* 9-17-41, 126 plants, *9779;* 4-4-41, *D. J. Stouffer,* 6 plants, *9285;* 6-22-41, 1 plant, *9343;* Oct. '40, 20 plants, *9175;* 12-29-40, 10 plants, *9239;* 1-16-41, 11 plants, *9250;* 9-4-41, *W. H. Long & D. J. Stouffer,* 34 plants, *9494;* 9-14-41, 4 plants, *9766; D. J. Stouffer,* 4-1-41, 12 plants, *9268;* 3-7-41, 13 plants, *9826;*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Cougar Mt. area, 11–8–40, 10 plants, *9284;* 30 miles from Corona, 3–31–41, 15 plants, *9283;* Corona area, 5–25–41, 35 plants, *9809;* 1–14–42, 37 plants, *9992.*

18. GEASTER LIMBATUS, (black European form), Fr. Syst. Myc. 3: 15. 1829 (FIG. 21)

Geaster limbatus Fries var. *pacificus* Morse, Mycologia **33**: 139–142. 1941

Sporophore hypogeous in leaf debris with both a universal and basal mycelium, becoming superficial and expanded at maturity, then 2–6 cm. across. *Exoperidium* revolute, splitting to the middle. *Rays* broad, 7–12, acute, subequal, not hygroscopic, more or less vaulted, or some involute under spore sac, rays often splitting again at the tips which are occasionally involute. *Fleshy layer* adnate, thick, rarely splitting and flaking off, usually of same color as the spore sac, when not weathered, natal brown to avellaneous on some freshly expanded plants, then a lighter color than the spore sac. *Exterior* covered with leaf debris, deciduous only after long weathering. *Base* concave, often showing a strong umbilical scar from the basal mycelial strand. *Endoperidium* pedicellate, pedicel often flattened and with a pronounced apophysis, subglobose to depressed-globose, natal brown often with a white bloom, 10–25 mm. across, rarely weathering to dingy white. *Mouth* definite, often somewhat depressed, fibrillose, usually concolorous with the endoperidium. *Gleba* seal brown. *Columella* slender or inevident. *Spores* globose, 4–5.5 μ in diameter. *Epispore* dark brown, strongly verrucose.

Habitat: In leaf debris under *Juniperus monosperma* in our region.

Distribution: NEW MEXICO, Corona area, 9–5–41, *W. H. Long & D. J. Stouffer,* 9 plants, *9667;* 25 miles N.W. of Corona, 11–27–41, *D. J. Stouffer,* 8 plants, *9931;* Parida Canyon near Willard, 11–11–41, 4 plants, *9942;* Corona area, 4–17–42, *W. H. Long,* 27 plants, *10105;* 9–17–41, *W. H. Long & D. J. Stouffer,* 59 plants, *9763;* Atkinson Ranch, 25 miles from Corona, 12–15–41, *D. J. Stouffer,* 37 plants, *9961;* Corona area, 9–17–41, *W. H. Long & D. J. Stouffer,* 67 plants, *9778;* 20 miles north of Corona, 4–2–41, *D. J. Stouffer,* 13 plants, *9518;* Cougar Mt., 9–15–40, 7 plants, *9165;* Corona area, July, '40, *W. H. Long & D. J. Stouffer,* 33 plants, *8722;* 4–20–40, 61 plants, *8725;* 12–29–40, *D. J. Stouffer,* 31 plants, *9238;* 4–17–40, *W. H. Long &*

FIGS. 15–20, × 1. *Geaster;* 15, *G. minimus* (type of *G. juniperinus* from Herb. Morgan), 2 plants; 16, *G. minimus,* usual form, 3 plants; 17, *G. arenarius,* 4 plants; 18, *G. tomentosus,* 4 plants; 19, *G. coronatus,* 4 plants; 20. *G. Hieronymi,* 2 plants.

D. J. Stouffer, 51 plants, *8723;* Indian Springs, 7700 ft., 9–5–41, *D. J. Stouffer,* 1 plant, *9186.*

GEASTER LIMBATUS (light colored American form, FIG. 22)

The black European form of *G. limbatus* is very common under *Juniperus monosperma* in the Corona region but we have not found it outside of this territory; although we have seen three plants of the same species from Berkeley, California, where it is again found under junipers but not *J. monosperma.* Miss Morse (**1941**) described it as a new variety of *Geaster limbatus,* but we do not think that it deserves a varietal name judging from the three plants we have seen from her. Under our distribution we have listed the black form separately from the typical form in the three states discussed.

The pale form is lighter in color than the typical form and much more varied in the colors of the fleshy layer and spore sac and differs also in other minor features. Its colors vary from fawn color to Hays brown or pale to pinkish buff for the fleshy layer, whereas spore sac or endoperidium varies in individual collections from eucre-drab to drab gray to plain drab; in old weathered plants often dingy white. Except for the colors, the characters are fairly constant. We are therefore holding all these color variations under the same name *Geaster limbatus,* but have described the black form in our technical diagnosis and have given photographs of both.

We have found only the black form under junipers whereas the lighter colored form is found under a variety of conifers and hardwoods, and, as our records show, it is much more widely distributed. We have compared our black form with a specimen from Dr. Hollós of Hungary and the two are comparable in every major detail.

Distribution: ARIZONA, Ft. Valley Exp. Station near Flagstaff, under pines, 7–1–15, *W. H. Long,* 1 plant, *5406;* Mt. Mingus, Prescott Nat. For., 7000 ft., 5–18–34, 2 plants, *8812;* Prescott area, 5–15–33, 8 plants, *8870;* Chiricahua Nat. Monument, Bonito Canyon, under *Cupressus arizonica,* 11–25–33, *W. H. Long & V. O. Sandberg,* 36 plants, *7856;* Grand Canyon, Arizona, August, '30, *Dr. R. B. Street,* 1 plant, *8967;* Workman Creek, Tonto Nat. For. in hardwood duff, 9–27–46, *D. J. Stouffer,* 1 plant *11405;* Eagle District, Crook Nat. For., 3–24–47, *11454.* NEW MEXICO, Pecos, 5–10–16, *W. H. Long,* 7 plants, *5682;* Tres Ritas, Penasco Canyon, 11–5–11, 13

plants, *8857;* Gila Nat. For. Leg. *Page,* 1 plant, *8160; W. H. Long,* 1 plant, *10011;* Silver City, 7500 ft., 7–23–33, 5 plants, *8965;* 10 plants, *8858;* Pecos Town, 2 plants, *8867;* Corona area, 9–5–41, *W. H. Long, & D. J. Stouffer,* 8 plants, *9533;* Red Cloud Picnic Grounds, 4–16–42, 1 plant, *10241;* Indian Springs, 8–31–41, *D. J. Stouffer,* 2 plants, *9818;* Corona area, 9–6–41, 13 plants, *9569;* 4–16–42, *W. H. Long & D. J. Stouffer,* 10 plants, *10053;* 4–20–42, 1 plant, *10226;* 4–15–42, 5 plants, *10235;* 7 plants, *10240;* 4–21–40, 8 plants, *8741;* 9–17–41, 12 plants, *10010;* Sept. '40, *D. J. Stouffer,* 7 plants, *9828;* 72 plants, *9168;* 9–17–41, 28 plants, *9778;* Tejano Canyon near Albuquerque, Oct. '16, *W. H. Long,* 1 plant, *5631;* 6–25–22, 3 plants, *8766;* 1916, 1 plant, *5580;* Corona area, March, '39, *D. J. Stouffer,* 5 plants, *8465;* 4–28–41, 2 plants, *9327;* Jicarilla, Lincoln County, 5–6–41, 6 plants, *9316;* 9–16–40, *W. H. Long & D. J. Stouffer,* 3 plants, *9762;* Mimbres Valley, 5–22–35, *W. H. Long,* 2 plants, *9025;* Tres Montosas Mts. near Magdalena, 10–11–34, *A. E. Frazier,* 1 plant, *8893;* 20 miles N.W. of Corona, 7–23–41, *D. J. Stouffer,* 5 plants, *9550;* Gran Quivera Road, 4–21–42, *W. H. Long & D. J. Stouffer,* 9 plants, *10107;* Atkinson Ranch, 4–21–42, 7 plants, *10205.*

19. GEASTER SACCATUS Fr. Syst. Myc. 3: 16, form MINOR Lloyd Myc. Writ. 1: 111. 1902 (FIG. 23)

Sporophore hypogeous, in black soil becoming superficial and expanded at maturity, then 1.5–2 cm. across. *Exoperidium* semirevolute, flaccid, not hygroscopic, splitting to middle or slightly beyond. *Rays* 6–7, broad, subequal, acute, not long pointed, saccate to shallowly saccate. *Fleshy layer* adnate, not rimose, pecan brown when not weathered, often aging to burnt umber. *Exterior* with a small amount of soil often attached. *Base* flat, concave or convex, some with a slight umbilical scar. *Endoperidium* sessile, papyraceous, not flaccid in any plants, saccate to subsaccate, subglobose, 8–10 mm. across, cinnamon drab to benzo brown, with a circular ridged peristome. *Peristome* prominent, concolorous or slightly lighter than the surrounding tissue, of a different texture, *Mouth* low, conical. *Gleba* sepia to seal brown. *Columella* globose. *Capillitium* hyaline, 4–5 μ thick, unbranched. *Spores* globose, 4–4.5 μ in diameter. *Epispore* verruculose.

Habitat: In black soil under barbed wire fences and under trees on Hickory Creek.

Distribution: TEXAS, Denton, *W. H. Long,* no. *7470,* 1 plant in Lloyd Myc. Coll. no. *24991* as *Geaster* sp.; Nov. '02 (Long no. *1815*), 2 plants in Lloyd Myc. Coll. no. *52585;* 1–10–03 (Long no. *7474*), 3 plants in Lloyd Myc. Coll. no *22652;* 1–12–05 (Long no. *7478*), 4 plants in Lloyd Myc. Coll. no. *51283;* 10–10–07 (Long nos. *2028 & 2068*), 10 plants in Lloyd Myc. Coll. no. *52469* (named *Geaster arenarius* but certainly not that species); Austin, 1900, *W. H. Long,* 1 plant, *11198;* 3–2–03, *W. H. Long & A. M.*

Ferguson, 3 plants, *11195;* and 6 plants, *11194;* Quitman, *W. H. Long*, 3 plants, *4541.*

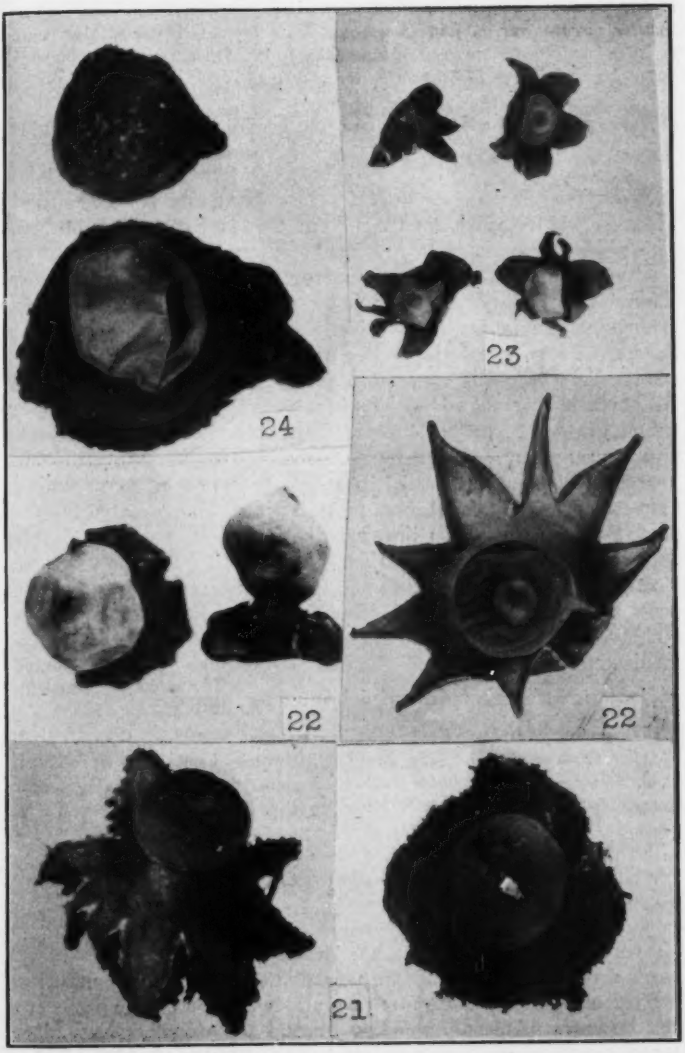
Farmers in plowing their prairie fields in the vicinity of Denton, Texas, during 1900–1910, where barbed wire fences were used, began plowing on the perimeter of the fields, going round and round toward the center. The dirt from the first furrow next to the fence usually fell on the area under the fence, thereby covering all trash, green and dead vegetation. The green buried grass and weeds of course will die and soon rot, as this process is repeated year after year on both sides of the fence, these fence rows in time will have more humus and decaying vegetable matter than the open fields; this produces good feeding grounds for certain fungi. This explains the habitat listed as "in black soil under barbed wire fences."

20. GEASTER TRIPLEX Jungh. Tidjschr. v. Natuurl. Ges. 7: 287. 1840 (FIG. 24)

Sporophore hypogeous in leaf debris, becoming superficial and expanded at maturity, then 3–8 cm. across, button globose or acute. *Exoperidium* explanate to revolute, rigid but not hygroscopic, splitting to or beyond the middle. *Rays* 4–6, broad, acute, often long acuminate, subequal, many revolute under the spore sac, rigid, thick. *Fleshy layer* more or less cracking and peeling off, army brown. *Exterior* more or less covered with dirt and debris. *Endoperidium* sessile, subsaccate, 2–2.5 cm. across, sayal brown to dingy white with long weathering. *Mouth* sometimes flaccid and nearly empty of spores, definite, seated in a definite area, concolorous or slightly darker than the endoperidium, of a different texture, often fimbriate, short conical. *Gleba* warm sepia to bister. *Columella* inevident to clavate. *Capillitium* dark brown, 3–7 μ thick. *Spores* globose, 4–6 μ in diameter. *Epispore* verrucose.

Habitat: In leaf debris under trees.

Distribution: ARIZONA, Flagstaff, July, '15, *W. H. Long*, 19 plants, *5520;* Casa Creek, 9–4–38, *C. O. G.*, 12 plants, *8268;* Workman Creek area, Tonto Nat. For., *D. J. Stouffer*, 9–17–46, 16 plants, *11407;* Eagle District, Crook Nat. For., 3–24–47, 2 plants, *11444;* Mt. Graham, 5–8–47, 1 plant, no. *11459.* NEW MEXICO, Eureka Lodge near Cuba, 9–7–31, *W. H. Long*, 1 plant, *8849;* Cloudcroft, Aug. 1899, *E. O. Wooten comm. W. A. Archer*, 1 plant, Lloyd Myc. Coll. no. *16481;* Organ Mts., 1907, 1 plant, Lloyd Myc. Coll. no. *21054.* TEXAS, Denton, 1908, *W. H. Long*, 1 plant, *8856;* Austin, 7–12–00, 3 plants,



FIGS. 21–24, × 1. 21, *G. limbatus*, black European form, 2 plants; 22, *G. limbatus*, light colored American form, 3 plants; 23, *G. saccatus*, form MINOR, 4 plants; 24, *G. triplex*, 2 plants.

11202; Denton (Long no. *7471*), 2 plants in Lloyd Myc. Coll. no. *52584* as *Geaster saccatus* var. *major;* (Long no. *7481*), 8 plants in Lloyd Myc. Coll. no. *51284* as *Geaster saccatus;* Huntsville, *J. W. Stiles,* no. *3,* 10 plants in Lloyd Myc. Coll. no. *51285* as *Geaster saccatus.*

21. GEASTER SACCATUS form MAJOR Lloyd Myc. Writ. 1: 111. 1902 (FIG. 25)

Sporophore hypogeous in leaf debris, becoming superficial and expanding at maturity, then 2.5–5 cm. across, button long beaked. *Exoperidium* explanate to revolute, brittle, usually splitting to or beyond the middle. *Rays* 6–8, narrow, subequal, acute with long acuminate points, not hygroscopic but rigid and very thin. *Fleshy layer* adnate, natal brown to raisin black, shining, thin, brittle, not rimose. *Exterior* practically free of dirt and debris, cinnamon, becoming light buff with age. *Base* plane or convex with or without an umbilical scar. *Endoperidium* sessile, papyraceous, subglobose, subsaccate, 1–1.5 cm. in diameter, fawn color fading to tilleul buff under weathering. *Mouth* large, usually strongly projecting before much weathering, seated in a definite depressed area, darker than endoperidium, hair brown to drab gray with age, often fimbriate. *Peristome* sorghum brown fading to wood brown, of different texture from the endoperidium, conical. *Gleba* mummy brown. *Columella* ovate, pointed. *Capillitium* hyaline to slightly smoky, walls thick, lumen small, 4–4.5 μ thick, walnut brown. *Spores* globose, strongly verrucose, subopaque, very dark brown, 4–5.2 μ in diameter.

Habitat: Gregarious in leaf debris under junipers.

Distribution: ARIZONA, Eagle District in Crook Nat. For., 3-24-47, *D. J. Stouffer,* 2 plants, *11444.* NEW MEXICO, Jicarilla, Lincoln County, 7-18-41, *D. J. Stouffer,* 7 plants, *9543;* 5-21-41, 5 plants, *9450;* Ranger Tank near Corona, 5-12-41, 14 plants, *9329;* Jicarilla, Lincoln County, 9-16-41, *W. H. Long & D. J. Stouffer,* 15 plants, *9757.*

22. GEASTER FORNICATUS (Huds.) Fr. Syst. Myc. 3: 12. 1829 (FIG. 26)

Sporophore hypogeous in leaf debris with both universal and basal mycelium, becoming superficial and fornicate at maturity, 3–6 cm. across. *Exoperidium* revolute, bending strongly backward and downward, usually splitting beyond the middle. *Rays* 4–5, rarely more, subequal, tips attached to the fornicate mycelial layer, not hygroscopic, but thick and rigid. *Fleshy layer* dark brown to burnt umber, thick, more or less peeling off and leaving the surface of the fibrous layer naked and pecan brown. *Exterior* my-

celial layer stripped off from the fibrous layer when evagination occurs and remaining as a hollow cup attached to the tips of the revolute rays, often with a large hole in center where the basal mycelial mat was located. *Base* concave. *Endoperidium* pedicellate, stalk usually white when not weathered, subglobose to depressed-globose to urceolate, usually constricted at base into an apophysis, light drab to drab to cinnamon drab to often blackish brown, soft, finely velvety, 1–2 cm. across. *Mouth* indefinite without peristome but usually lighter in color than the endoperidium, conical to tubular apex which is often fibrillose to lacerate, sometimes white. *Gleba* seal brown. *Columella* inevident. *Capillitium* 3–5 μ thick, dark brown. *Spores* globose, 4–5 μ diameter. *Epispore* umber, finely verrucose.

Habitat: Gregarious in leaf debris under conifers and hardwoods.

Distribution: ARIZONA, Sabino Canyon area, 11–11–38, *W. H. Long,* 2 plants, *8265;* 2–20–38, *W. H. Long & V. O. Sandberg,* 9 plants, *7681;* 8 miles of Nogales, 11–10–38, *W. H. Long,* 13 nearly black plants, *8264.* NEW MEXICO, 25 miles N.W. of Corona, 4–20–40, *W. H. Long & D. J. Stouffer,* 260 plants, *8748;* Corona area, 9–15–41, *W. H. Long & D. J. Stouffer,* 56 plants, *9665;* Sept. '40, *D. J. Stouffer,* 35 plants, *9122;* Atkinson sandhill area, 25 miles west of Corona, 12–15–41, 13 plants, *9967;* 4–21–42, *W. H. Long & D. J. Stouffer,* 30 plants, *10211;* Corona area, *D. J. Stouffer,* 2–19–40, 7 plants, *8459;* 20 miles N.W. of Corona, 1–2–41, *D. J. Stouffer,* 11 plants, *9246;* Corona area, 4–17–42, *W. H. Long,* 2 plants, *10080;* Willard in Parida Canyon, 11–29–41, *D. J. Stouffer,* 3 plants, *9941;* Corona area, 7000 ft. elevation, 2–28–40, 82 plants, *8475;* 4–21–40, *W. H. Long & D. J. Stouffer,* 21 plants, *8727;* 34 plants, *8475;* 4–20–40, 2 plants, *8697;* Cougar Mt. area, 4–21–40, 5 plants, *8694.* TEXAS, Austin, 1901, *W. H. Long,* 2 plants, *346;* 3–2–03, *W. H. Long & A. M. Ferguson,* 1 plant, *11190; W. H. Long,* 1 plant, *11438;* and 2 black plants, *11188* (Long no. *346*), in Lloyd Myc. Coll. no. *52482.*

This species is very common and in great numbers in the vicinity of Corona, New Mexico, especially under *Juniperus monosperma.* Specimens are often found which have been pushed out of the debris by the alternate thawing and freezing of the soil, thereby making them easily visible to the collector where before they were very inconspicuous.

23. GEASTER RUFESCENS (Pers.) Fries, Syst. Myc. 3: 18. 1829 (FIG. 27)

Sporophore hypogeous in soil, becoming superficial and expanded at maturity, then 5–7 cm. across. *Exoperidium* explanate to revo-

lute to involute under the spore sac, very rigid but not hygroscopic, splitting to the middle or beyond. *Rays* 5–6, broad but acute, subequal, some involute at base of spore sac, rigid, thick. *Fleshy layer* thick, often porous and spongy, or cracked but not peeling off, Vandyke brown. *Exterior* more or less covered with dirt and debris, which often peels off under weathering leaving the rays naked beneath. *Endoperidium* very short stipitate, stipe thick with a broad apophysis, 2–2.5 cm. across, pecan brown to pinkish buff. *Mouth* indefinite, without a definite border, naked, concolorous or slightly darker. *Gleba* sepia. *Columella* globose. *Capillitium* 4–5 μ thick, sub-hyaline. *Spores* globose, 4–5 μ in diameter. *Epispore* slightly verruculose.

Habitat: In soil.

Distribution: NEW MEXICO, White Mts. near Ruidoso, 10–10–16, *W. A. Archer*, no. *14*, 1 plant, Lloyd Myc. Coll. no. *30423*. TEXAS, Houston, 1–1–17, *George L. Fisher*, no. *61*, 2 plants, Lloyd Myc. Coll. no. *53493;* Denton, 12–22–08, *W. H. Long*, 1 plant, *2108;* Bryan, in Brazos County, 3–15–36, *Dr. Walter Ezekiel*, 2 plants, *8449*.

24. GEASTER FIMBRIATUS Fr. Syst. Myc. 3: 16. 1829 (FIG. 28)

Sporophore hypogeous in leaf debris, becoming superficial and expanded at maturity, then 1.5–4 cm. across. *Exoperidium* revolute, flaccid, splitting to the middle. *Rays* 8–11, subequal, acute, not hygroscopic, tips turning under when completely expanded, leaving the base shallowly saccate. *Fleshy layer* adnate, often rimose or splitting, pecan brown to walnut brown. *Exterior* covered with leaf debris which often peels off at the tips, exposing the underside of the rays, then pale pinkish buff to cartridge buff. *Base* concave, not umbilicate. *Endoperidium* sessile, often with a white pruinose bloom, subglobose, more or less saccate, 10–22 mm. in diameter. *Mouth* indefinite, naked, usually slightly lighter in color, and shading into the surrounding tissue. *Gleba* sepia. *Columella* subglobose, rather prominent. *Capillitium* brown. *Spores* globose, dark brown, 3–4 μ diameter. *Epispore* minutely verrucose.

Habitat: Gregarious in leaf debris at high altitudes 6000–9000 feet, under pines and junipers.

Distribution: ARIZONA, Santa Catalina Mts. near Tucson, 1911, *W. H. Long*, 1 plant, *8855*. NEW MEXICO, 1916, *W. H. Long*, 2 plants, *2657;* Pecos Cienega Ranger Station, 9–30–14, 15 plants, *4159;* Oct. '14, 8000 ft., 10 plants, *4502;* Pecos, 1 plant, *9146;* 1916, 2 plants, *5673;* Indian Springs, Gallinas District, 9–15–40, *D. J. Stouffer*, 22 plants, *9549;* Corona area, 9–15–40, 2

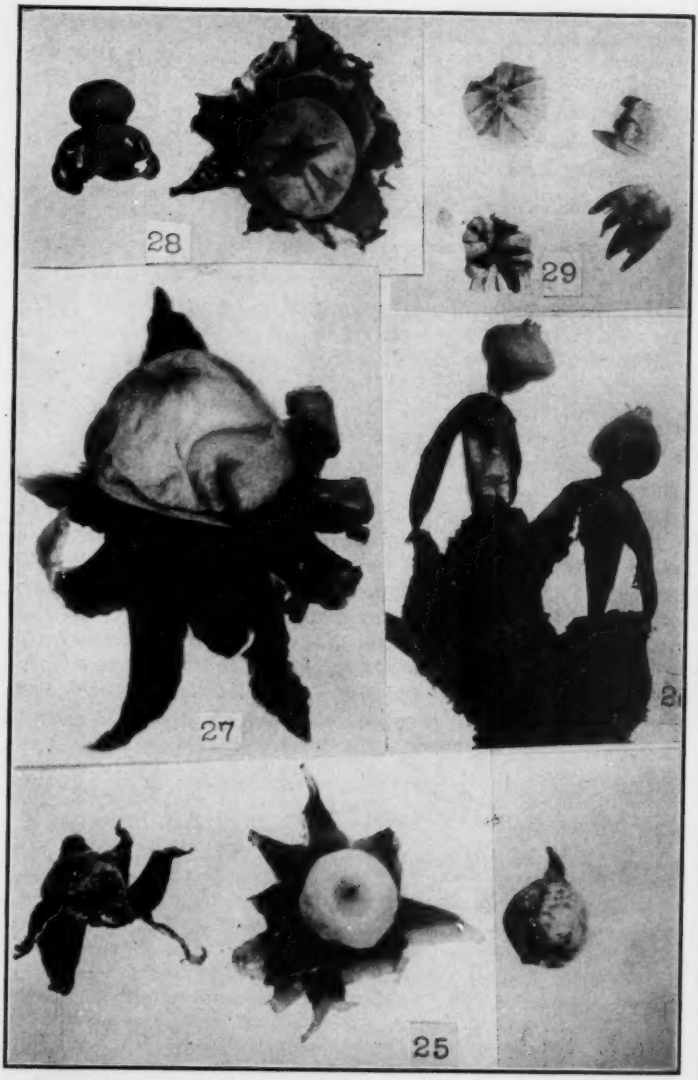
plants, *9163;* April, '41, 1 plant, *9328;* 4–4–40, 3 plants, *9272;* Oct. '40, 1 plant, *9177;* Sept. '40, 3 plants, *9127;* 9–17–40, *W. H. Long & D. J. Stouffer,* 9 plants, *9876;* 9–4–41, 2 plants, *9511;* Ranger Tank, 5–12–41, *D. J. Stouffer,* 6 plants, *9313;* 30 miles N.W. of Corona, 3–31–41, 1 plant, *9282;* near Lookout Tower, 9000 ft., 2 plants, *9557;* Indian Springs, 7700 ft., 9–5–40, *W. H. Long & D. J. Stouffer,* 245 plants, *9514.* TEXAS, Austin, 7–17–00, *W. H. Long,* 1 plant, *11120;* Bastrop, 7–9–42, *W. Z. M.,* 1 plant, *11439.*

25. GEASTER FLORIFORMIS Vitt. Mon. Lyc. p. 23. 1842, p. 167. 1843 (FIG. 29)

Sporophore hypogeous with a universal mycelium, becoming superficial and expanded at maturity, then 1–2.5 cm. across. *Endoperidium* revolute when wet, strongly hygroscopic, splitting one half to two thirds the way to middle. *Rays* 6–12, very unequal, acute, rigid, hygroscopic and usually involute over the spore sac, covering it entirely, with the tips revolute when expanded. *Fleshy layer* adnate, continuous, not rimose, walnut brown to sepia. *Exterior* at first covered with a thin layer of mycelium and dirt, usually peeling off and leaving the lower surface of the fibrillose layer clean and free of dirt, then usually white, often with a white pruinose surface which shows up fine when the plants are wet, rarely pecan brown. *Base* convex to plane when rays are expanded, not umbilicate. *Endoperidium* sessile, membranous, 0.5–1 cm. diameter, subglobose, minutely furfuraceous to glabrate in age, not asperate, wood brown to army brown. *Mouth* indefinite, small, irregular, usually plane but rarely with a slight raised tube opening. *Gleba* umber to blackish brown. *Columella* inevident. *Capillitium* subhyaline, about as thick as spores. *Spores* globose, 4–7 μ diameter. *Epispore* distinctly verrucose.

Habitat: Solitary or gregarious in small groups, in partial shade of piñons, pines and other desert vegetation.

Distribution: ARIZONA, Sabino Canyon area, 9–28–39, *W. H. Long,* 1 plant, *8775;* 1–4–38, 1 plant, *8771;* Flagstaff, 5–6–34, 15 plants, *8980;* Nogales area, on Highway 87, 9–11–41, *W. H. Long & D. J. Stouffer,* 5 plants, *9690;* Blue River area, Eagle Ranger District, Crook Nat. For., 3–24–47, 10 plants, *11446.* NEW MEXICO, Corona area, 9–6–41, *W. H. Long,* 54 plants, *9567;* 9–4–41, *W. H. Long & D. J. Stouffer,* 20 plants, *9502;* Jornado Exp. Range, 9–8–41, 2 plants, *9716;* White Sands National Monument, 9–13–41, 2 plants, *9755;* 10 miles west of Deming, 9–12–41, 1 plant, *9700;* Dulce, near Stone Lake, *Ledru Savage & R. L. Turney,* 6–25–34, 12 plants, *9023;* San Ysidro, 7–19–41, *W. H. Long,* 3 plants, *9382;* Eureka Lodge near Cuba, 8300 feet elevation, 11–1–37, *W. H. Long,* 2 plants, *9079.* TEXAS, Denton, Pecan Creek, 9–17–07, *W. H. Long,* 20 plants, *2004;* 10–10–07, 13 plants, *2028;* Amarillo, 12–13–09, 28 plants, *2113;* Denton, 9–17–07 (Long no. *2004*),



FIGS. 25–29, × 1. 25, *G. saccatus* form *major*, 3 plants; 26, *G. fornicatus*, 2 plants; 27, *G. rufescens*, 1 plant; 28, *G. fimbriatus*, 2 plants; 29, *G. floriformis*, 4 plants.

Lloyd Myc. Coll., 4 plants, *4726;* 1–12–03 (Long no. *1791*), 39 plants, Lloyd Myc. Coll., *4752;* 10–22–06 (Long no. *1802a*), *27* plants, Lloyd Myc. Coll. *4758;* Dec. 1902 (Long no. *1780*), 9 plants, Lloyd Myc. Coll. *4761;* 6 plants, Lloyd Myc. Coll. *4773.*

TERROSTELLA Long, Mycologia **37**: 601–607. 1945

Geasteroides Long, Mycologia **9**: 271. 1917.

Peridium double; *exoperidium* splitting into stellate, reflexed, persistent segments; *endoperidium* fragile, upper portion more or less deciduous, lower part persistent, consisting of a prominent sterile base; *mouth* single, *columella* and *capillitium* present.

TERROSTELLA TEXENSIS Long, Mycologia **37**: 605–607. 1945 (FIG. 30)

Geasteroides texensis Long, Mycologia **9**: 271. 1917.
Geasteropsis texensis (Long), Ed. Fischer, Engler & Prantl, Pfl. Ed. 2, 7A; 75. 1933.

Sporophore hypogeous, becoming superficial and expanded at maturity, then 4–10 cm. across, usual size 6 cm. *Exoperidium* revolute, thick, coriaceous, subhygroscopic, splitting to about the middle. *Rays* 7–10, unequal, revolute, often with strongly involute acuminate tips 2–4 cm. long. *Exterior* with an outer layer of arachnoid mycelium and dirt that peels off as the plants age, leaving the exposed surface tilleul buff to dingy white, often with faint longitudinal striae. *Fleshy layer* adnate, carob brown, fissured, cracked when dry, gradually wearing away. *Base* concave below and convex above. *Endoperidium* short pedicellate, subglobose, drab gray to light gray, 15–25 mm. broad by 18–20 mm. high, very fragile, apparently with a poorly defined mouth, upper portion slowly deciduous down to the sterile base, leaving it crowned with the subglobose columella and spores. *Sterile base* corky, compact, wood brown to fawn color, circular to oblong, circular ones 10–15 mm. across by 8–10 mm. tall, oblong ones 10 × 20 mm. to 25–27 mm. across by 10 mm. tall. *Pedicel* terete to strongly flattened, stout, subligneous, 2–4 mm. thick by 3–15 mm. wide by 2 mm. high. *Gleba* chestnut brown in very old plants, entirely disappearing and leaving only the sterile base seated on the pedicel (FIG. 30). *Columella* soft, weak, early deciduous. *Capillitium* wine color to light brown under the microscope, threads very long, distantly branched, 7–10 mm. thick, septate in the thicker portions, breaking up into segments 800–1000 μ long, walls smooth. *Spores* globose,

uniguttulate, 3–5 μ in diameter. *Epispore* brown, 1 mm. thick, faintly verruculose.

Habitat: Solitary or gregarious in small groups, around base of old rotting oak stumps (*Quercus stellata*) in open post-oak woods.

Distribution: TEXAS, Denton, 620 feet elevation, *W. H. Long*, 9–28–06, 4 plants, *1671;* 10–8–07, 14 plants, *2011;* 6 plants, *2034;* Pecan Creek, 3 plants, *2035.*

The distinguishing features of this species are its prominent corky sterile base and its fragile deciduous endoperidium. Specimens are deposited as follows: 6 plants from type material in Lloyd Myc. Coll. no. *8787* as *Trichaster texensis,* an herbarium name; 4 plants from type material are in the Herbarium of the University of California at Berkeley, no. *53941,* under the name *Geasteroides texensis;* the remainder of the collections are in the Long Herbarium at Albuquerque, New Mexico.

ASTRAEUS Morg. Jour. Cin. Nat. Hist. Soc. **12**: 19. 1889

Sporophore hypogeous with basal mycelium, becoming superficial at maturity. *Exoperidium* as in *Geaster. Endoperidium* membranous, dehiscent at apex, by a single mouth. *Columella* none. *Capillitium* long, much branched, originating from the inner surface of the peridium. *Spores* large, globose.

ASTRAEUS HYGROMETRICUS (Pers.) Morg. Jour. Cin. Soc. Nat. Hist. **12**: 20. 1889 (FIG. 31)

Geastrum hygrometricum, Pers. Syn. Fung. p. 135. 1801.
Geastrum fibrillosum Schw. Naturf. Gesell. p. 113. 1822.
Geaster vulgaris Corda, Icones Fung. **5**: 64. 1842.
Astraeus stellatus (Scop.) E. Fischer in E. & P. Aufl. 1 Teil 1, Abt. 1**: 341. 1900.
Geaster hygrometricus Pers. var. *giganteus* Lloyd. Myc. Writ. 1: 68. 1901.

Sporophore hypogeous, becoming superficial and expanded at maturity, then 1–8 cm. across. *Exoperidium* involute under or over the spore sac, rigid, splitting to the center of the base. *Rays* 7–20, usually very unequal, acute, strongly hygroscopic. *Fleshy layer* whitish when fresh, soon deciduous and leaving a rough rimose surface which may be mouse gray to benzo brown. *Exterior* free of dirt and debris, exposing the underside of the rays which are usually dingy white to cartridge buff. *Base* plane to convex, not umbilicate. *Endoperidium* globose to depressed-glo-

bose, sessile, 1–3 cm. in diameter, pitted or reticulate, whitish, becoming gray to brownish in age. *Mouth* an irregular torn aperture. *Gleba* sepia. *Columella* none. *Capillitium* much branched, threads hyaline, thinner than the spores. *Spores* globose, variable in size, 7–10 μ, average about 9 μ. *Epispore* verrucose.

Habitat: Solitary or gregarious in small groups in soil in open or partial shade areas, in sandy or clay soils.

Distribution: ARIZONA, Tucson, Santa Catalina Mts., 5-18-34, *N. L. Noecker & R. C. Robeson*, 10 plants, *9027;* Pinal Mts., 8-1-34, 6 plants, *9016;* between Miami and Superior, 9-11-32, *O. F. Cook*, 4 plants in Myc. Coll., Bureau of Plant Industry; 6 plants, 1922, *C. R. Orcutt* in Myc. Coll., Bureau of Plant Industry; Huachuca Peak, 6-14-34, 4 plants, *9028;* Young, Tonto Nat. For., Aug. '34, 12 plants, *7969;* Williams, 7-12-33, *W. H. Long*, 16 plants, *8885;* Grand Canyon, Aug. '30, *Dr. R. B. Street*, 3 plants, *7888;* Flagstaff, Fort Valley Experiment Station, 7-1-15, *W. H. Long*, 10 plants, *5407;* 10-15-15, 4 plants, *5479;* 10 miles from Flagstaff, 5-2-33, 10 plants, *8852;* 7-1-33, 7 plants, *8978;* June, '33, 6 plants, *7801;* Bill Williams Mt., near Flagstaff, 6-21-30, *J. F. Normand*, 9 plants, *8866;* Prescott, 2-16-34, *V. O. Sandberg*, 6 plants, *7616;* 7-12-33, *W. H. Long*, 11 plants, *7768;* 6 plants, *7825;* 8 plants, *8850;* 8-1-33, 6 plants, *8962;* 1-3-33, 8 plants, *9058;* Sitgreaves Nat. For., 11-15-45, *D. J. Stouffer*, 1 plant, *11083.* NEW MEXICO, Corona area, 4-17-42, *W. H. Long & D. J. Stouffer*, 7 plants, *10060;* State College, 1907, *F. O. Wooten*, comm. *W. A. Archer*, 1 plant, Lloyd Myc. Coll. no. *50121;* 4-17-42, Red Cloud Picnic Grounds, 8300 ft., 36 plants, *10216;* Oak Shinnery, 34 miles east of Roswell, on Highway 380, 4-19-42, 53 plants and 7 eggs, *10106;* Santa Fe area, 7-19-36, *J. N. O'Bryan*, 2 plants, *5619;* near old Alamos School area, 8200 ft., 5-10-33, *W. H. Long*, 10 plants, *8877;* 7-12-41, 5 plants, *9406;* Tejano Canyon, 7-30-16, 16 plants, *5655;* 5-19-16, 6 plants, *5672;* near Taos, 6-25-33, *T. R. Moberg*, 4 plants, *7823;* Tres Ritas, Cienega Canyon, 10-19-14, *W. H. Long*, 6 plants, *4463;* Silver City, 7-26-36, 14 plants, *8245;* 7-7-33, 6 plants, *8982;* 1911, 4 plants, *8868;* Animas Mts., 7-26-34, *N. L. Noecker & R. C. Carlson*, 14 plants, *8785;* Corona area, 9-15-41, *W. H. Long & D. J. Stouffer*, 6 plants *9753;* Jicarilla, Lincoln County, 9-16-41, 5 plants, *9763.* TEXAS, Denton, *W. H. Long*, 1907, 16 plants, *2054;* Bastrop, 11-14-36, 1 plant, *11192;* Valentine, 9-25-32, *E. W.*, 2 plants, *11181;* Austin, 3-2-1903, *W. H. Long & A. M. Ferguson*, 1 plant, *11121;* San Antonio, June, '32, *H. B. Parks*, 5 plants, *11187;* Austin, 7-1-01, *W. H. Long*, 2 plants, *11440;* (his no. *1826*), *19101*, 4 plants, Lloyd Myc. Coll. no. *57090;* Tyler, 1892, *Wm. R. Harris*, 7 plants in Myc. Coll., Bureau of Plant Industry.

Cunningham (**1944**) transferred this plant back to the genus, *Geaster* (*Geastrum*), with the following explanation (p. 178): "The treatment of this species by certain taxonomists well illustrates the pitfalls that lie in wait for those who worship at the shrine of ontogenetic classification. Morgan was the first to claim

that the plant which for nearly a century had been regarded as a typical *Geastrum*, differed sufficiently in several characters to warrant its being placed in a separate genus; to this he gave the name *Astraeus*, his reasons for its erection being that the species did not possess a regular hymenium or columella, the spores were larger than those of any other, and the capillitium showed certain differences from the other species.

"The only feature of those outlined in which the species differs from others of *Geastrum* is the somewhat primitive hymenium. In the developing plant the glebal cavities are separated by tramal plates to tenuous as to be overlooked by the uncritical worker. Each cavity is filled with basidia somewhat irregularly arranged in clusters (like those of *Scleroderma*) and not in the definite palisade of the species which have been studied. This difference disappears as maturity is reached, when the plants resemble closely the fructification of any other member of the genus. The taxonomist is then unable to indicate any point of difference by which '*Astraeus*' may be separated from *Geastrum*, which indicates that the name should be discarded.

"Morgan was content to retain the plant in the Lycoperdaceae; not so Fischer (1900), however, for without regard to the absurdity of such a treatment, he placed *Astraeus* in the Calostomataceae. And Kambly & Lee (1936) proceeded further and isolated it under the Astraceae of Martin!"

We are holding the genus *Astraeus* in deference to the general opinion of many recent taxonomists, but personally we incline to handling it as Cunningham has. We believe that after all the *mature* stage of a species, irrespective of any embryonic stages through which it might have passed and which have disappeared on maturity, should be the basis for its classification. The taxonomist can judge only by the characters found in the mature stage, now present and visible, where the plant should be placed.

MYRIOSTOMA Desv. Jour. de Bot. **2**: 103. 1809

Sporophore hypogeous, becoming superficial at maturity. *Exoperidium* coriaceous, splitting in a stellate manner. *Endoperidium* membranous, opening by several to many mouths, columellae several, slender. *Capillitium* threads free, unbranched.

MYRIOSTOMA COLIFORME (Dicks.) Corda, Anleit., p. 204. 1842 (FIG. 32)

Bovistoides simplex Lloyd, Myc. Writ. **6**: 883. 1919.

Sporophore hypogeous with a basal mycelial strand, often in leaf debris becoming superficial and expanded at maturity, then 2–12 cm. across. *Exoperidium* revolute, splitting from one fourth to nearly the middle. *Rays* 8–14, very unequal, tips often involute. *Fleshy layer* adnate when fresh, thick, often becoming deciduous in extreme old age, then cartridge buff to avellaneous, cinnamon to sayal brown when not weathered, becoming walnut brown under weathering, then thick and peeling. *Exterior* more or less with fine leaf debris or dirt but the dirt clinging to the concavity of the base. *Base* concave to vaulted, often showing a large umbilical scar where the mycelial strand was attached. *Endoperidium* on many having very short, inconspicuous pedicels, depressed-globose to subglobose, 1–5 cm. in diameter when not weathered, light cinnamon drab (silvery brown), cinnamon drab, to drab gray in age, minutely roughened with small subreticulate warts. *Mouths* several to many, ciliated, naked, apparently as many as the number of pedicels, mainly on upper half of spore sac. *Gleba* bone brown to burnt umber. *Columellae* several to many, usually inevident in the mature gleba, but apparent at base of spore sac. *Capillitium* long, slender, free, tapering, unbranched, 2–5 μ thick, with thick walls. *Spores* globose, 4–5 μ diameter. *Epispore* strongly warted.

Habitat: Gregarious in sandy soil, often in partial shade of trees.

Distribution: ARIZONA, Cardey, 4–1–36, *V. O. Sandberg,* 1 plant, *7722;* Sabino Canyon area, *W. H. Long,* 11–10–38, 1 plant, *8309;* 9–28–39, 4 plants, *8404;* 2–20–34, 1 plant, *9621; W. H. Long & V. O. Sandberg,* 9–22–30, 2 plants, *8020;* 2–20–34, 2 plants, *7684;* 11–10–39, *W. H. Long,* 1 plant, *8247;* Eagle Creek District, Crook Nat. For., 3–31–47, *D. J. Stouffer,* 15 plants, *11451.* NEW MEXICO, Corona area, 5–2–39, *D. J. Stouffer,* 1 plant, *8375;* 2 plants, *8460;* 4–3–40, 1 plant, *8695;* Aug. '40, 3 eggs, *8759;* Cougar Tank, 10–1–38, 6 plants, *8696;* Corona area, 21 plants, *9167;* Atkinson Ranch, 25 miles west of Corona, 12–15–41, 9 plants, *9968;* 4–7–42, 9 plants, *10099;* 4–15–42, 1 plant, *10238;* 4–20–42, *W. H. Long,* 15 plants, *10118;* 4–16–42, *W. H. Long & D. J. Stouffer,* 2 plants, *10054;* Atkinson Ranch, 25 miles west of Corona, 4–21–42, 4 plants, *10213;* Corona area, Jan. '40, *D. J. Stouffer,* 1 plant, *8441;* 9–17–41, *W. H. Long & D. J. Stouffer,* 3 plants, *9782;* 9–14–41, 32 plants, *9761;* 9–17–41, 18 plants, *9736;* 9–15–41, 15 plants, *9666;* 28 plants, *9119;* Nov. '39, *D. J. Stouffer,* 9 plants, *8442;* 3–31–41, 30 miles N.W. of Corona, 12 plants, *9284;* 4–21–40, *W. H. Long & D. J. Stouffer,* 31 plants, *8729;* July, '40, *D. J. Stouffer,* 62 plants, *8710;* Corona area, 7–28–40, 68 plants, *8711.*

32
31
31
30

This species was very common and in large numbers in the Corona region as the above distribution records show. Long (**1942**) examined the type of *Bovistoides simplex* Lloyd and found that it was an old spore sac of a much weathered and depauperate specimen of the old and well known species, *Myriostoma coliforme*, which had become detached from the outer stellate exoperidium.

ACKNOWLEDGMENTS

We are indebted to Mr. John A. Stevenson for the loan of material and for many helpful suggestions and to Miss Edith K. Cash for editing the Latin diagnoses.

ALBUQUERQUE, NEW MEXICO
SAFFORD, ARIZONA

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FIGS. 30–32. 30, *Terrostella texensis*, 3 plants; 31, *Astraeus hygrometricus*, 3 plants; 32, *Myriostoma coliforme*, 1 plant; all × 1.

TAXONOMIC NOTES ON LOUISIANA FUNGI—II. TREMELLALES

LINDSAY S. OLIVE

(WITH 3 FIGURES)

In this paper will be found descriptions of a number of jelly fungi collected in Louisiana during the past year. Since there seem to be few reports on this group of fungi in Louisiana, most of them will represent new records for the area. Twenty-seven species are included, four of which appear to be heretofore undescribed. It is expected that a considerably larger number of these interesting Heterobasidiomycetes will eventually be added to the present list.

EOCRONARTIUM MUSCICOLA (Fr.) Fitzp. Phytopath. **8**: 212. 1918 (FIG. 2: 1–11).

This interesting fungus, which represents the type and only known species of the genus, is said to have a wide distribution. The elongate, slender fructifications, whitish at first and later yellowish tinged, were found growing on the sporophytes of a moss, probably a species of *Amblystegium*. They measure 4–7 mm. in length and are generally slightly swollen above. The texture is subfleshy. The hymenium covers almost the entire surface.

The fungus produces clavate, thin-walled probasidia from which the basidia arise. Fitzpatrick (**1918**) has shown that nuclear fusion occurs in the probasidium, followed by meiosis during the development of the basidium. The four-celled basidium is finally cut off at its base from the empty probasidium. The probasidium is never such a distinctly differentiated structure as is found in such fungi as the rusts. Furthermore, it is obvious that the probasidium is not of a sufficient size to produce a mature basidium by itself. Part of the contents of the basidium must be derived, during its formation, from the hypha bearing the probasidium.

The cells of the basidium produce conspicuous sterigmata of varying lengths. The basidiospores produced upon them are typically

falcate and measure 4.7–7 × 21.8–31.3 μ. These spores frequently germinate by repetition.

Parasitic on sporophytes of a moss, probably *Amblystegium* sp., swampy woods near the campus, Baton Rouge, Louisiana; May 7, 1947; W. J. Dickson.

AURICULARIA AURICULARIS (S. F. Gray) Martin. Amer. Midl. Nat. **30**: 81. 1943.

Numerous auriform fructifications of the "ear fungus" were found growing on rotten wood of a fallen deciduous tree. The collection was made in a woods near Baton Rouge, February 9, 1947.

HELICOGLOEA LAGERHEIMI Pat. Bull. Soc. Myc. Fr. **8**: 121. 1892 (FIG. 1: 8–20).

This is one of the most widespread and also one of the most variable species in the genus. The genus is characterized by effuse, resupinate fructifications that are floccose and dry to soft-gelatinous in texture, and by the production of lateral, saccate probasidia that give rise to four-celled, transversely septate basidia. Two collections, varying considerably in certain microscopic characters, have been made in this area. In view of the variable nature of the species, the writer does not consider these to be of varietal significance.

The first specimen (FIG. 2: 8–14) was found growing on the underside of a dead oak limb lying on the ground. The fructifications are thin, not very extensive, and soft-gelatinous in texture. The surface is uneven and the color is grayish hyaline to gray. The probasidia, which are over 20 μ long, and which are often characterized by having one or two constrictions, arise terminally on the hyphae, or sometimes in an intercalary position. They give rise to characteristic four-celled, rust-like basidia. The basidiospores in this collection are obovate and measure 6.1–7.6 × 8.4–11.4 μ. This falls within the range, 4–13 × 8–25 μ, given by Baker (**1941**), who has monographed the group.

The second collection (FIG. 1: 15–20) was obtained on the bases of old leaf petioles and fruiting stalks of the windmill palm.

The fructifications are similar in most respects to those of the first collection. Some of them have a somewhat pustular appearance and an olive-gray color. They dry to a thin, rough, olive-gray to dark layer. The hyphae, which are without clamp connections, measure 2.5–6 μ in diameter. The probasidia are terminal or rarely intercalary in origin and measure 9.6–12.2 × 29.6–48.7 μ. They germinate to produce basidia that measure 8.7–10.4 × 66–125 μ. The basidiospores are cylindrical, straight or slightly curved, and measure 8.7–12.2 × 22.6–29.6 μ. They frequently germinate by repetition. As can be seen by referring to the range given above, the basidiospores of this specimen reach a greater length than in any previously described collection. This further emphasizes the extreme variability of the species.

Both collections made on or near the campus, one on dead oak limb, March 2, 1947; the second on dead bases of petioles and fruiting stalks of the windmill palm, May 30, 1947.

Helicogloea sebacinoidea sp. nov. (FIG. 1: 1–7).

Fructificationibus firmiter gelatinosis, sordide fusco-brunneis, latitudine ad centimetrum cubicum unum cum semisse patentibus, 2.5–4 cm. longis, 150–765 μ crassis; superficie inaequali, verrucis parvis et nigris tecta. Hyphis typos duos habentibus, quorum alter hyphas angustas et brunneas 0.8–3 μ diametro, alter hyalinas hyphas latiores 3.8–12.2 μ diametro producit.

Probasidiis typice curvatis, per superficiem matricis gelatinosae hyphis maioribus effectis, origine et terminalibus et intercalariis, 10–14 × 25–50 μ metientibus; basidiis transverse septatis, quattuor cellulas habentibus, rectis vel curvatis, 6.3–7.8 × 70–122 μ metientibus; basidiosporis elongatis, rectis vel curvatis, 5.2–8.7 × 10–14.5 μ, uniseptatis frequenter exsistentibus. Haec species in ramo quercus demortuo crescit.

Fructifications up to 1.5 cm. broad and 2.5–4 cm. long, 150–765 μ thick, firmly gelatinous, color a dark sordid brown, not closely adherent to the substratum and separable from it, surface irregularly ridged and undulate, covered with small black warts consisting of conglomerate masses of dark hyphae, drying to a thin blackish brown crust and often curling back at the margins. Hyphae of two types, the narrow, brownish, much-branched hyphae most abundant, 0.8–3 μ in diameter, extending throughout the fructification but forming a dense surface layer above and below; large branched hyphae less numerous, 3.8–12.2 μ in diameter, extending to the upper surface of the fructification and producing the probasidia externally to the gelatinous matrix. Probasidia mostly curved, rarely straight, typically more swollen distally, both termi-

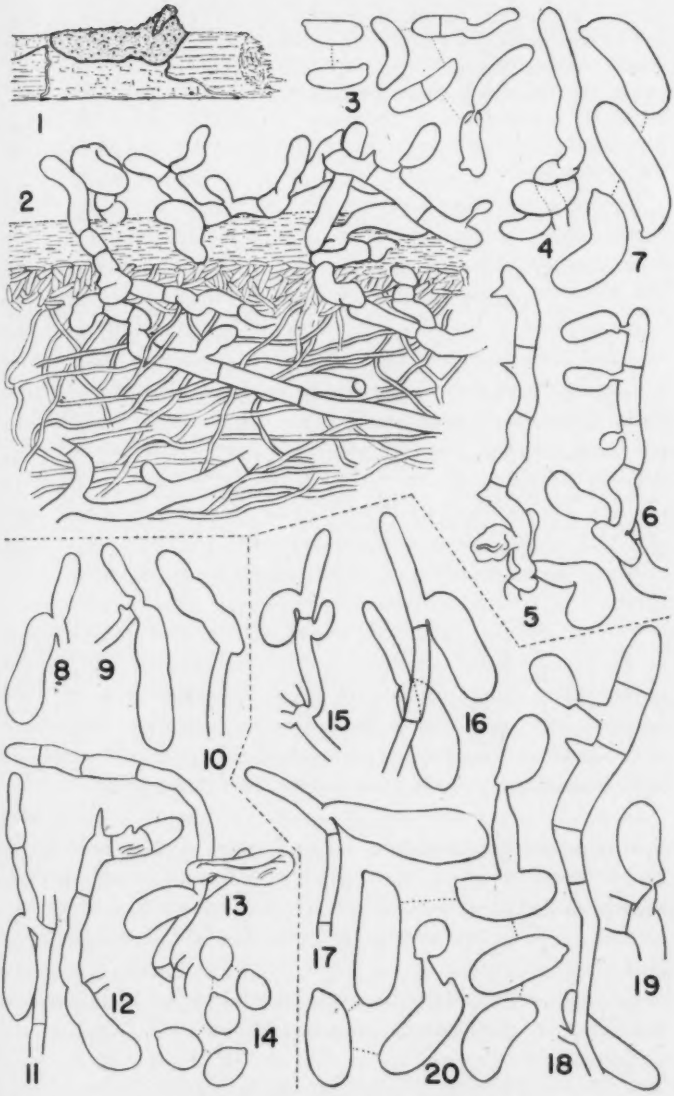

FIG. 1. Louisiana Tremellales.

nal and intercalary in origin, measuring 10–14 × 25–50 μ, giving rise to transversely septate, four-celled basidia, basidia straight or curved, measuring 6.3–7.8 × 70–122 μ, producing four basidiospores on relatively short sterigmata; basidiospores cylindrical, apiculate, straight to conspicuously curved, 5.2–8.7 × 10–14.5 μ, germinating by repetition or becoming one-septate and germinating with germ tubes.

According to Baker's monograph (**1936**) of the genus *Helicogloea,* the fructifications of the various species vary in texture from mucous-gelatinous to floccose. In a more recent paper (**1946**), in which she gives a key to all the known species (eleven in number) of *Helicogloea,* she states: "The genus falls naturally into two lines depending upon the character of the fructification, which may be of the mucous-gelatinous ('tow-like') type, or the distinctly floccose (hypochnoid) type." The fungus described by the present writer, however, does not come within these limits, since its fructifications are decidedly firmly gelatinous. In other respects also the fungus differs from all previously described species in the genus. It now appears necessary to extend the concept of the genus to include forms with distinctly gelatinous fructifications.

The brown color of the fructifications is contributed primarily by the surface layer of narrow interwoven hyphae. The interior is only lightly tinted with brown. A most interesting feature of the fungus is the production of the probasidia just above the surface of the gelatinous matrix. As a result of this, both probasidia and basidia are entirely exposed throughout their development.

In general appearance and in texture the fungus is remarkably like some species of *Sebacina.* Even on drying, it resembles to a certain extent *S. adusta* Burt, which also frequently folds back at the margins when it dries. However, the dark warts over the surface would serve to distinguish it in the field from species of *Sebacina.*

Growing on a small corticate oak branch lying on the ground, in the vicinity of Shreveport, Louisiana; July 4, 1947.

TREMELLA LUTESCENS (Pers.) Fr. Syst. Myc. 2: 213. 1822.

The conspicuous orange-yellow, contorted fructifications of this jelly fungus were found to contain both the conidial and basidial

stages. The basidiospores measure 7.8–10.4 × 12.2–15.7 μ. The fructifications were found on dead corticate limbs of frondose trees. Some grew on the dead but still attached branches of a locust. The collections were made in the vicinity of Baton Rouge; February and March, 1947.

Tremella rufobrunnea sp. nov. (FIG. 3: 4–18).

Fructificationibus gelatinosis, inaequaliter plicatis, colorem siennae ustae habentibus, ad centimetrum cubicum semis altis, 0.8–2.2 cm. latis; superficie minutis punctis (vesiculis) tecta. Hymenio magnas vesiculas brunneas, 14.8–48.7 μ diametro, conidia sphaerica usque ad formam praelongam, 2.7–4.6 × 2.7–8.4 μ, atque basidia subglobosa usque ad formam globosam, verticaliter septata, 13.7–17.9 μ diametro continente; basidiosporis ovalibus, 6.6–8 × 9.1–12.5 μ. Haec species in frondoso ligno demortuo crescit.

Fructifications gelatinous, gyrose-folded, up to 0.5 cm. high and 0.8–2.2 cm. broad, color burnt sienna, surface minutely brown punctate when viewed with a lens (due to presence of globose vesicles protruding onto the surface singly or in groups); shrinking on drying and becoming dark brown or dark reddish brown. Hyphae with abundant and conspicuous clamp connections; hymenium containing conidia, basidia, and sterile vesicles; conidia produced with clamps at their bases, light yellowish-brown under the microscope, spherical to oblong or cylindrical, measuring 2.7–4.6 × 2.7–8.4 μ; vesicles numerous, brown, inflated and somewhat thick-walled at maturity, protoplasmic contents eventually disappearing and wall often gelatinizing, many of them protruding onto the surface of the fructification, 14.8–48.7 μ in diameter; basidia subglobose to globose, vertically septate, four-celled, the cells frequently showing a tendency to separate, 3.7–17.9 μ in diameter; basidiospores mostly oval, apiculate, 6.6–8 × 9.1–12.5 μ, germinating by repetition.

The fungus appears to be most closely related to *Tremella lutescens* (Pers.) Fr. (syn. *T. mesenterica* [S. F. Gray] Pers.), which has also been described as frequently containing inflated sterile cells similar to the vesicles of the new species. The two further resemble each other in their production of conidia and in the size of their basidia and basidiospores. On the other hand, the new fungus differs from *T. lutescens* in the decidedly different color of its fructifications, its less erect nature, the minutely brown-punctate surface, the color of the conidia and vesicles, and in the presence of a much larger number of inflated vesicles in the hymenium.

These characters seem to warrant separation of the two as distinct species.

Two collections of the fungus have been made. The first collection was found to be sterile. Its hymenial layer was filled with the sterile brown vesicles, but no basidia were observed. The specimen was found near Baton Rouge, but was discarded before the one described here was found.

Growing on dead corticate frondose limb, Avery Island, Louisiana; April 20, 1947.

TREMELLA FUCIFORMIS Berk. Hooker's Jour. Bot. 8: 277. 1856 (FIG. 2: 28–33).

Although the specimen described here differs in some respects from previous descriptions of *T. fuciformis*, there are many characters which indicate that it is that species. The fructifications occur singly or in patches up to 6 × 10.5 cm., while the individual fructifications measure 1.5–3.5 cm. in width and 0.7–1.2 cm. high. They vary from nearly translucent to opaque white in color, firmly gelatinous at first, becoming soft and mucilaginous, often sordid tinted, with age. The surface is much contorted or folded. The bases of the fructifications spread out into a yellow cartilaginous layer beneath the bark of limbs upon which the fungus is growing. The fructifications dry to a thin, yellowish, horny layer, or sometimes they merely shrink somewhat and retain some of their original form.

The hyphae are provided with clamp connections. Conidia are produced abundantly along with the basidia. These conidia appear in chains from the ends of some of the hyphae and are provided with clamp connections at their bases. They are subglobose to oval or elliptical, measure 5–9 μ in diameter, and bud out smaller conidia of variable size. The basidia are four-celled, vertically or often obliquely septate, and measure 9.1–11.4 × 11.4–16 μ. The basidiospores are broadly ovate and apiculate. They measure 4.6–7.4 × 6.8–11.6 μ. They may germinate by repetition or bud out small conidia. The basidial cells and sterigmata also frequently bud out similar conidia.

This collection differs from previous descriptions of the fungus mainly on the basis of its larger basidia and basidiospores. Burt

(1921) states that the basidia measure 6–7.5 × 7–10 μ and the spores 4–4.5 × 5.6 μ. Coker (1920) says that the spores are around 6.2 μ in diameter. No one apparently has observed the presence of conidia in the hymenium. However, an examination of one of the specimens described by Coker revealed their presence. Our collection agrees well with Coker's in texture, color, size, and hymenial structure.

Growing on corticate oak limb, Colyell Bay, March 9, 1947.

TREMELLA MYCOPHAGA var. OBSCURA Olive. Mycologia **38**: 540. 1946.

This interesting fungus was discovered originally as a parasite of *Dacrymyces,* namely *D. deliquescens, D. minor,* and *D.* sp. It has been previously reported only in Georgia and North Carolina. The present collection extends the host range to another genus of the Dacrymycetaceae. The fungus was found growing within the fructifications of *Dacryomitra stipitata,* where it produced both conidia and basidiospores in typical fashion. Collected near Varnedo, Louisiana; October 11, 1946.

EXIDIA SPICULOSA (S. F. Gray) Somm. Supp. Fl. Lapp. 307. 1826.

This and *Exidia recisa* are the most common jelly fungi in our area, as they seem to be throughout most of the country. The fungus is common on dead frondose wood all through the year. The writer has one collection of it on dead corticate pine branches. The fructifications were much more flattened out on the substratum than usual, but agreed in all other respects with the previous descriptions. The writer has found no previous record of this fungus on coniferous wood.

EXIDIA RECISA (S. F. Gray). Syst. Myc. *2*: 223. 1822.

Like the foregoing species, this fungus is common throughout the year on dead frondose limbs.

EXIDIA NUCLEATA (Schw.) Burt. Ann. Mo. Bot. Gard. 8: 371. 1921.

The plant is easily recognized by its pinkish to vinaceous fructifications with white calcareous nodules embedded in them. A collection was made on a corticate oak limb, wooded area on edge of campus; June 22, 1947.

SEBACINA CINEREA Bres. Fungi Trid. 2: 99. 1892 (FIG. 3: 2 and 3).

The fructifications in our single collection of the fungus are thin, gray to grayish tan in color, and rather soft-waxy. The species is particularly characterized by the presence of golden colored, clavate to cylindrical gloeocystidia in its fructifications. The basidiospores are oblong or broadly cylindrical and measure 4.6–6.3 × 9.5–12.2 μ. These measurements fall within those given by McGuire (**1941**).

Growing on corticate and decorticate parts of an old oak limb, woods at edge of campus; June 22, 1947.

SEBACINA EYREI Wakef. Trans. Brit. Myc. Soc. **5**: 126. 1915 (FIG. 3: 1).

Our collection of this species is characterized by its thin, waxy, grayish colored fructifications and its rather small cylindrical gloeocystidia, which become yellowish in color. The basidiospores are globose and distinctly apiculate. They measure 4.2–5.3 μ in diameter. The fungus corresponds very well with the description given by McGuire (**1941**).

Growing on a corticate frondose limb, Avery Island, Louisiana; April 20, 1947.

SEBACINA EPIGAEA (B. & B.) Bourd. & Galz. Hymen. Fr. 39. 1928.

In this collection, the fructifications are composed of small waxy-gelatinous, white to tan pustules. The basidiospores measure 7.5–9.6 × 11.3–14.4 μ. One of the most characteristic features of this fungus is the tendency of its spores to become transformed into angular resting cells with somewhat thickened walls.

The fungus was collected in a single locality on a dead corticate oak limb and on the underside of some very old cow dung, wooded area near Baton Rouge; February 9, 1947.

SEBACINA ADUSTA Burt. Ann. Mo. Bot. Gard. 2: 764. 1915 (FIG. 1: 34–39).

The species has been frequently collected in this area. Its fructifications are effuse, waxy gelatinous to firmly gelatinous in texture, and dark brown or grayish brown in color. The surface is uneven and bumpy. The fructifications dry to thin, black, parchment-like layers which frequently split away from the hyphal layer next to the substratum and curl back around the margins.

The numerous paraphyses in the hymenium become encrusted with small brownish granules, which are probably primarily responsible for the brown color of the fungus. The paraphyses often gelatinize, after which the granules become scattered in the hymenium. Larger calcareous granules are also present in the fructifications. The basidiospores are curved-cylindric and measure 3.8–5.3 × 9.9–16.7 μ.

This is probably the most common species of *Sebacina* in our area. It has previously been reported only in Idaho and British Columbia. Our collections agree rather well with McGuire's description, except that the fructifications are decidedly gelatinous in texture rather than fleshy.

Collected on dead frondose wood and on the dead bases of leaves and fruiting stalks of windmill palm. Common in this area throughout the year.

Sebacina variseptata sp. nov. (FIG. 2: 12–27).

Fructicationibus effusis, exilibus, firmiter gelatinosis, fumo-griseis ad colorem olivaceo-griseum, superficie inaequali, parvis villis hypharum agglutinatis tecta. Hyphis confibulas habentibus, paraphysibus simplicibus vel ramosis, numerosa granula brunnea continentibus. Granula calcarea quoque in fructificationibus insunt. Probasidiis typice reticuliformibus, ad figuram pyriformem aut ovoideam variantibus, basidiis quattuor cellulas habentibus, septis typice obliquis vel transversis, aliquando verticalibus, 7–10 × 10.6–23 μ; basidiosporis allantoideis, 3.8–5.3 × 10.6–13.7 μ. Haec species in frondoso ramo demortuo collecta est.

Fructifications resupinate, thin, somewhat cartilaginous-gelatinous, smoke gray to olive gray, surface bumpy and covered with whitish tapering tufts of agglutinated hyphae; occurring in broken patches for an extent of 19 cm. along the limb, up to 5 cm. broad; drying to a thin tan to dark brown vernicose layer. Hyphae provided with numerous clamp connections, paraphyses simple or

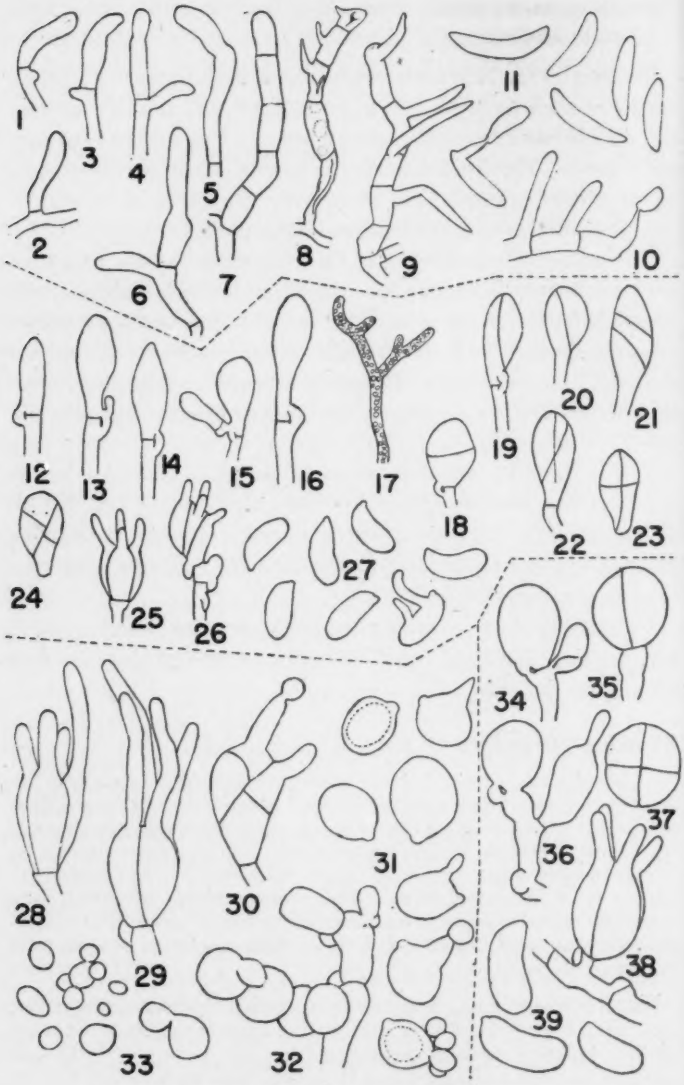

FIG. 2. Louisiana Tremellales.

branched, becoming filled with brownish granules, disintegrating and leaving the granules scattered through the hymenium; numerous calcareous granules also present in the fructification. Probasidia mostly clavate at first, typically swelling above and becoming racquet-shaped, or sometimes varying to pyriform or ovoid, commonly proliferating from clamp connections at their bases; basidia four-celled by means of septa which are typically oblique to transverse or sometimes vertical, measuring 7–10 × 10.6–23 μ; basidiospores allantoid, 3.8–5.3 × 10.6–13.7 μ, mostly germinating by means of germ tubes.

The closest related form in the genus *Sebacina* appears to be *S. adusta*, which the new fungus resembles in several respects. The two are very similar in texture and in the structure of the hymenium. Both have the characteristic small brown granules in the hymenium, as well as larger calcareous granules scattered through their fructifications. They are further alike in the shape and size of their basidiospores. On the other hand, the fungus described differs markedly from *S. adusta* in the great variability of its basidia and in its appearance when dry. In the present species, basidia with all septa vertical are rare, whereas basidia with all septa transverse to oblique are quite common. Moreover, these basidia are typically racquet-shaped, with a stalk-like base, and many of them reach a considerably greater length than do those of *S. adusta*. The latter species typically produces only ovate or obovate basidia in which the septa are all vertical. Also, the new species, when dry, does not split back around the margins as is characteristic of *S. adusta*.

In its basidial development, *S. variseptata* resembles to a great extent another tremellaceous fungus, *Patouillardinia cinerea* Bres., which has basidia characterized by transverse to oblique septa at right angles to each other. The two also have a somewhat similar texture, similar basidiospores, and calcareous granules scattered through their fructifications. The basidia of *P. cinerea*, however, are much longer, and there are other differences between the two. However, the fungus described here seems to represent an intermediate type which further links *Patouillardinia* phylogenetically with the genus *Sebacina*.

Collected on a corticate frondose limb, Avery Island, Louisiana; April 20, 1947.

SEBACINA PODLACHICA Bres. Ann. Myc. **1**: 117. 1903.

Our collections for the most part fall well within the description given by McGuire (**1941**). An important point that does not seem to have been sufficiently emphasized is the frequent tendency of this and some other species of *Sebacina* to persist for some time in the form of small separate pustules, rather than as a continuous layer. In this way, they have much of the appearance of a *Stypella* or a small *Exidia*. In one collection obtained here, these little pustules were observed scattered over a piece of dead wood. They were connected only by a few strands of hyphae encrusted with tiny calcareous granules. The pustules were sporulating at this time. The resemblance to *Stypella* was outstanding. However, when the collection was placed in a moist chamber and in a cool environment for a few days, the pustules began to coalesce and assume the appearance of a typical *Sebacina* fructification. A somewhat similar phenomenon has been observed by the writer in *S. epigaea*.

The fungus appears to be fairly common in the state throughout the year on dead wood of frondose trees. Collected around Baton Rouge and Shreveport.

DACRYMYCES ABIETINUS var. **triseptata** var. nov. (FIG. 3: 19 and 20).

Fructificationibus pulvinatis, aurantinis ad colorem pallide flavum, firmiter gelatinosis, 2.5–10 mm. diametro, usque ad quinque centimetra cubica altis, frequenter coalescentibus. Basidiosporis maximam partem triseptatis, raro ad septem septa habentibus, 6.1–8.3 × 12.2–22 μ, conidia globosa ad ovoidea progemmantibus 2.1–4.5 μ diametro. In pini ramis demortuis crescit.

Fructifications pulvinate, orange yellow to light yellow, fading with age, firmly gelatinous, later becoming soft, surface generally contorted, often cerebriform, individual fructifications measuring 2.5–10 mm. in diameter and up to 5 mm. high, some with small white radicating bases, coalescing into larger masses. Clamp connections absent, basidia typical, basidiospores measuring 6.1–8.3 × 12.2–22 μ, becoming mostly three-septate with age, some up to seven-septate, budding out small globose to ovoid conidia, 2.1–4.5 μ in diameter, or giving rise to germ tubes.

The fungus differs from previous descriptions of *D. abietinus*

(Pers.) Schroet. mainly on the basis of its larger fructifications and in the tendency of the great majority of its spores to become only three-septate, rather than seven-septate. Even after the specimen was left in the moist chamber for several weeks, by far the majority of its spores remained three-septate. Rarely, a few were observed with as many as seven septa. Also the basidiospores are, on the average, somewhat shorter than in *D. abietinus*. Previous descriptions of this species indicate that the basidiocarps vary from 0.5–4 mm. in diameter. A specimen collected in Georgia by the writer (**1947**) had basidiocarps that were 0.5–1.6 mm. in diameter. On the other hand, the new variety has fructifications that measure 2.5–10 mm. in diameter. The contorted appearance of these fructifications is also a distinctive feature. All of these differences are believed sufficiently important to distinguish the fungus as a new variety of *D. abietinus*. They do not seem of great enough significance to warrant separation of the fungus as a different species.

Growing on corticate and decorticate parts of some dead pine limbs lying on the ground, campus; March 14, 1947.

DACRYMYCES DELIQUESCENS Duby. Bot. Gall. 729. 1829.

The species has been collected around Baton Rouge from fall to spring. It appears to be quite common here.

DACRYMYCES MINOR Peck. Ann. Rep. N. Y. State Mus. **30**: 49. 1877.

The fungus was collected in a wooded area adjacent to the campus, where it was found growing on corticate frondose wood. May 14, 1947.

DACRYMYCES ELLISII Coker. Jour. Elisha Mitchell Sci. Soc. **35**: 171. 1920.

Collected near the campus on a corticate frondose limb and on dead stems of a privet hedge; March and April, 1947.

DACRYMYCES PALMATUS (Schw.) Bres. Oesterr. Bot. Zeitschr. **54**: 425. 1904.

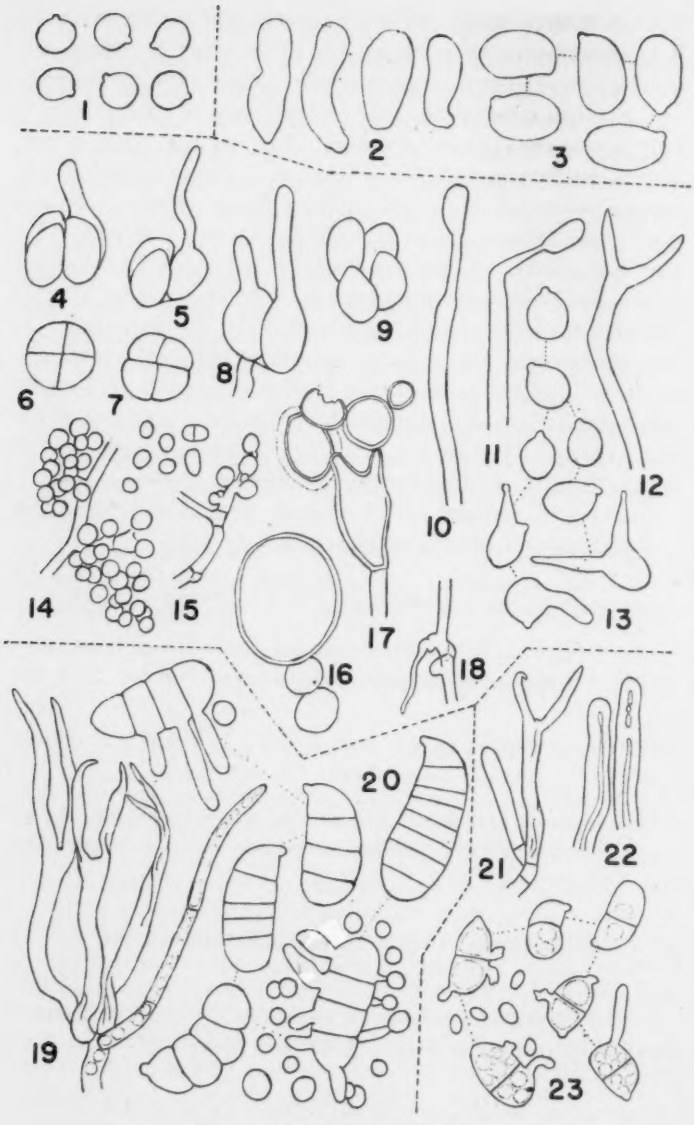

FIG. 3. Louisiana Tremellales.

Several large orange fructifications were found growing on a corticate pine log. The large basidiospores are seven-septate at maturity. Colyell Bay, Louisiana; March 11, 1947.

DACRYOMITRA STIPITATA (Peck) Burt. Ann. Mo. Bot. Gard. 8: 387. 1921 (FIG. 3: 21–23).

The small fructifications of this fungus arise singly or in groups from the substratum. They are elastic gelatinous and bright orange or orange-yellow in color. The fructification is usually provided with a small stalk and a pileus that is often somewhat convoluted or morchelloid and which is about 1–3 mm. broad. The fructifications are sometimes confluent near their bases, sometimes at the top. They measure 2.5–7 mm. in height.

The basidia are typical. The basidiospores are light yellow under the microscope. They become one-septate after being shed and measure 5.2–6.3 × 9.9–12.6 μ in one collection, 3.7–4.9 × 10.1–12.8 μ in another. The spores germinate to produce germ tubes or small globose to elliptical conidia.

This species seems to intergrade with *D. ceracea* (Coker) Brasf. with respect to most of its characters. They are certainly not distinguishable on the basis of color, texture, general structure, or basidiospore measurements. Brasfield (**1938**) considers *D. stipitata* and *D. ceracea* to be distinct species. In describing *D. ceracea,* he states: ". . . some basidiocarps may occur singly; when so, they are almost indistinguishable from *Dacryomitra stipitata* (Peck.) Burt; microscopically they are almost identical; however, the waxy consistency and the external appearance of *D. ceracea* serve to separate it readily from *D. stipitata;* the former is seemingly restricted to corticate oak wood." It is admitted in this statement that the two are sometimes macroscopically indistinguishable and that they are almost alike microscopically. The only other important criterion would appear to be the "waxy consistency." This latter concept, however, appears to be a mistake. Coker (**1920**) gave his fungus the specific name of *ceracea* because of the "deep wax-yellow" color of its fructifications and the "wax-colored" basidiospores. With regard to the texture of the basidiocarps Coker states that they are elastic gelatinous. In view of

these facts, the present writer can find no good reason for considering the two as distinct species. *Dacryomitra ceracea* (Coker) Brasf. is therefore considered here as being synonymous with *D. stipitata* (Peck) Burt.

Collected on dead corticate limbs of *Magnolia grandiflora* L., Varnedo, Louisiana; October 11, 1946, and on decorticate frondose wood, Baton Rouge; November 13, 1947.

GUEPINIA SPATHULARIA Fr. Elench. Fung. **2**: 32. 1828.

Collected twice on old fallen trunks of deciduous trees, vicinity of Baton Rouge; May and November, 1947.

CALOCERA CORNEA (Fr.) Link. Handb. Gew. **3**: 307. 1833.

Collected twice on unidentified dead wood near Baton Rouge; May and November, 1947.

ARRHYTIDIA INVOLUTA (Schw.) Coker. Jour. Elisha Mitchell Sci. Soc. **43**: 237. 1928.

In our single collection of this species, the fructifications are thin (2 mm. or less in thickness) and have coalesced into patches 0.3–2.7 cm. in diameter. They are tough-gelatinous, closely appressed, and have a warty or gyrose surface and fimbriate margin. The color is orange-yellow when moist. On drying, the fungus shows reddish orange portions against a yellowish corticioid subiculum. No clamp connections have been observed.

The basidia are bifurcate and typical of the group; the basidiospores become one- to three-septate and measure 5.1–6.3 × 12.6–17.1 μ.

Collected on dead corticate wood of cypress (*Taxodium*) Baton Rouge; October 21, 1946; W. J. Dickson.

GLOEOTULASNELLA PINICOLA (Bres.) Rogers. Ann. Myc. **31**: 199. 1933.

The thin and effuse gelatinous fructifications of this member of the Tulasnellaceae were found growing over the bark of a dead oak limb and over the surface of an old resupinate leather fungus

on the limb. The species is one of the most common and also one of the most variable in the family. It has been reported in many parts of this country as well as in Europe. Collected near Baton Rouge; March 11, 1947.

The writer is grateful to Dr. P. G. Moorhead, Head of the Department of Classical Languages, for his preparation of the Latin diagnoses.

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EXPLANATION OF FIGURES

FIG. 1. *Helicogloea sebacinoidea* (Nos. *1–7*). *1*, habitat sketch on dead wood; *2*, section through fructification, showing large and small hyphae, also probasidia and basidia produced externally; *3*, basidiospores, two-septate, one germinating by repetition; *4–6*, stages in basidial development; *7*, basidiospores much enlarged (No. *1*, × 1, nos. *2–6*, × 460, no. *7*, × 1060). *H. Lagerheimi* (Nos. *8–20*). 1st collection: *8–13*, probasidia and basidia; *14*, basidiospores (Nos. *8–14*, × 690). 2nd collection: *15–19*, stages in development of probasidia and basidia: *20*, basidiospores (Nos. *15–20*, × 570).

FIG. 2. *Eocronartium muscicola* (Nos. *1–11*). *1, 2*, probasidia; *3–7*, stages in development of basidia from probasidia; *8–10*, germination of the basidia; *11*, basidiospores (all × 460). *Sebacina variseptata* (Nos. *12–27*). *12–16*, stages in development of the probasidia; *17*, paraphysis with included granules; *18–26*, stages in basidial development (all × 690). *Tremella fuciformis* (Nos. *28–33*). *28, 29*, germinating basidia; *30*, germinating basidium with conidium arising from apex of young sterigma; *31*, basidiospores, some

budding out conidia; *32*, hypha bearing conidia; *33*, conidia, some budding in yeast-like manner (all × 690). *Sebacina adusta* (Nos. *34–39*). *34–38*, stages in basidial development; *39*, basidiospores (all × 690).

FIG. 3. *Sebacina Eyrei*. *1*, basidiospores (× 1060). *Sebacina cinerea* (Nos. *2* and *3*). *2*, gloeocystidia; *3*, basidiospores (× 1060). *Tremella rufobrunnea* (Nos. *4–18*). *4–9*, basidia; *10–12*, sterigmata; *13*, basidiospores, some germinating by repetition; *14*, *15*, hyphae bearing conidia; *16*, *17*, vesicles; *18*, hypha with clamp connections and appendage (all × 690, except *16* and *17*, × 460). *Dacrymyces abietinus* var. *triseptata* (Nos. *19* and *20*). *19*, group of empty basidia and paraphysis; *20*, basidiospores after septation, one germinating to produce microconidia, another producing germ tubes (all × 1060). *Dacryomitra stipitata* (Nos. *21–23*). *21*, probasidium and empty basidium; *22*, sterile, thick-walled cells from stalk of fructification; *23*, basidiospores, some germinating to produce germ tubes or microconidia (all × 1060).

AN EXAMINATION OF THE EXUDATE AND JUICE OF CERTAIN FUNGI FOUND IN THEIR NATIVE ENVIRONMENT

J. K. WILSON *

(WITH 1 FIGURE)

More than one hundred references exist in the literature relating to the exudative water given off by autotrophic and heterotrophic organisms. Certain ones referring to green plants go back about one hundred years whereas those referring to such organisms as fungi go back about seventy years. In these articles may be found data relating to the causes effecting such exudates as well as to their chemical composition. Since such exudates come from within the cell, any compound therein that is water soluble and can pass through the membrane of the cell may be found in the water. Little importance has been attached to this phenomenon but with our expanding knowledge of biotics, enzymes, phages, vitamins, viruses, and growth promoting substances such exudates should become of renewed interest. The early workers considered the exuded water to be about as pure as distilled water whereas later researchers found that the exudate from autotrophs may contain many substances although they may be present in relatively small amounts. The composition of water from certain autotrophic plants can be found in a paper by Wilson (**1923**).

Brefeld (**1872**) collected numerous drops from the surface of young sporangiophores of *Mucor Mucedo* and reported that the water had a weakly acid reaction. Wilson (**1881**) observed where such drops dried on the surface of the fungus—*Pilobolus crystallinus*—that they left radiating crystals, visible to the unaided eye. Lepeschkin in 1906, according to Buller (**1934**), analyzed the pressed juice and some of the exuded water from *Pilobolus lon-*

* Dr. Wilson passed away suddenly July 28. The proof of this article has been read by Prof. H. O. Buckman.

gipes. The pressed juice contained 4.1 per cent total solids whereas the exudate contained salts of the same nature but no organic substances were found in the latter. K, Na, Al_2O_3, Fe_2O_2, SO_3, P_2O_5, Cl, CO_2 and SiO_4 were recognized. The reaction of the drops was alkaline as determined by litmus paper and was due to K_2CO_3. The exuding did not occur at 0° C. but was abundant at 35° C.

Knoll (1912) analyzed the drops from several species of fungi and reported that they contained a slime readily soluble in water and that as the drops dried up they gave an irregular wrinkled appearance.

Those workers who studied the exudate from fungi obtained their samples from organisms cultured under controlled conditions whereas the data presented in this paper comprise a study of the exudates and juices obtained from certain fungi growing under natural environments.

OCCURRENCE AND COLLECTING OF THE EXUDATE

The principal collections of the exudative water were obtained from *Polyporus dryadeus*. This fungus was growing on an oak stump and observations on the process of exudation were made over a period of sixty days. A photograph of the fruiting body with its exudate as seen at the most active period is presented in fig. 1. Because the stump was in the shade a mirror was used to reflect light so that a satisfactory exposure could be made. At times the water was so profuse that the stump and the soil were thoroughly drenched. The exudate began to appear in the morning after sunrise when the temperature of the air was rising and stopped late in the morning or early in the afternoon. This was observed to be true in five separate locations. If a drop became so large that it fell off, another small one would usually appear in a few minutes and within twenty to thirty minutes, sometimes a shorter period, it might be large enough to fall. About 10 ml. was obtained at the time the picture was taken. This was collected by touching the drops with a clean glass rod and by transferring that which was collected to a test tube. At times a pipette was used. A similar procedure was followed for obtaining the drops on *P. sulphureus* and

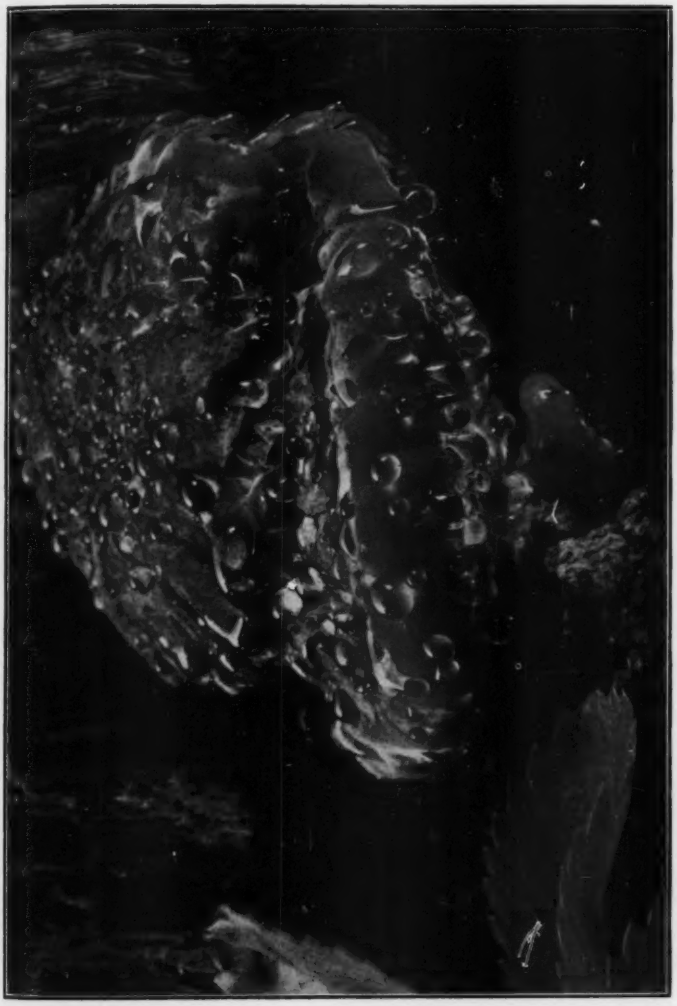


FIG. 1. Photograph of *Polyporus dryadeus* growing on stump of an oak tree. August 4, 1947. About three-fourths natural size. The drops appear often at the same spot day after day.

on *Fistulina hepatica* although solution water was found only twice on the latter fungus.

CHEMICAL COMPOSITION OF THE EXUDATE

Known weights of the filtered exudate from *P. dryadeus* were evaporated to dryness in a weighed platinum dish on a steam bath and the total solids ascertained. The latter varied from time to time and ranged from 1.7 to 2.72 per cent. The solids were composed of organic and inorganic substances. Bacteriological examination revealed that the water contained from 6,000 to 32,100 bacteria and actinomyces in each milliliter. Despite the acidity of the exudate the bacterial growth increased more than 10,000 in each milliliter if the exudate was held for 3 days, but the population declined by the sixth day so that it was about the same at it was at the beginning. Comprising this population were three species of bacteria and one of actinomyces. Transfers of the exudate from the fungus to sterile agar slopes by means of a sterile loop were made also and the same types of organisms were present. Employing the alkaline methylene blue reduction test for carbohydrates it was evident that reducing substances were present. Both the Schiff reagent and the Orcinol test gave positive reactions for formaldehyde. If the Schiff reagent is specific and will detect one part of formaldehyde in a million then it can be said that there were present in the exudate at certain times 40 p.p.m. of formaldehyde. Tests were made to detect the presence of oxalic acid. To the acidic exudate calcium chloride was added, then followed by ammonia in water. Also in other tests hydrochloric acid and calcium acetate were added, followed by ammonia. No test was positive. Toward the middle of the day when exuding was ceasing certain droplets became smaller. This apparently concentrated the solids so that the residue became attractive to black ants. Such findings support those of Neger (**1913**) who wrote that the mycelia in ant hills secrete small drops of liquid that were readily taken up by the ants. Analyses of the exudate from *P. dryadeus* for certain inorganic constituents were made following the recommendations by Peech and English (**1944**). Recorded in p.p.m. there were K 500, Mg 110, Ca 25, P 1, Fe 0.5 and no Al or Mn.

ACIDITY OF THE EXUDATE

The acidity of the exudate from *P. dryadeus*, *P. sulphureus* and from *Fistulina hepatica* was determined within 15 minutes after the drops were collected. The exudate was placed in a Pyrex glass sample holder and a clean glass electrode of a Beckman pH meter inserted. Readings were obtained from many samples of each during July and August except those of *F. hepatica* which was available only twice. The pH findings follow:

	pH
P. dryadeus	2.60–2.85
P. sulphureus	3.57–3.80
F. hepatica	3.60–3.80

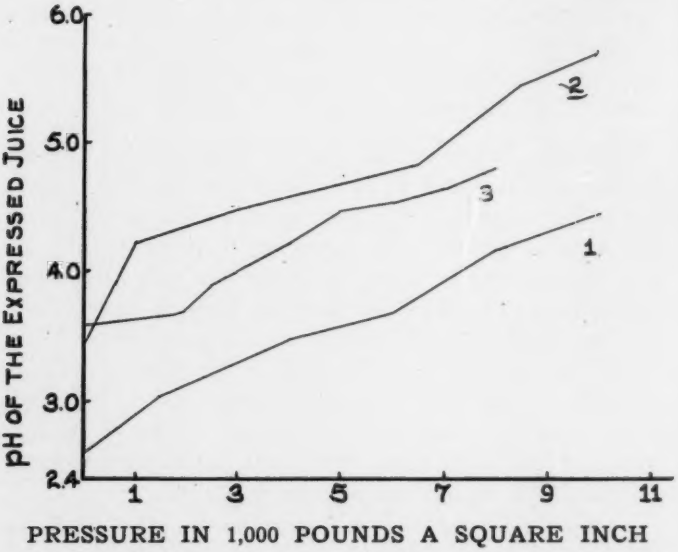
When collecting the exudate from *P. dryadeus* it was observed that the freshly exuded drops appeared perfectly clear whereas some of those that had fallen from one part of the growth to another and had remained there apparently for a considerable time were yellowish brown. Collections of the clear and of the colored exudate were obtained on the same day from the same growth. The clear liquid had a pH of 2.6 whereas that of the sample containing color was pH 4.4. The cause of this difference of color and acidity is unknown. It may be that certain parts of the growth yielded color that contaminated the exudate. Some of the clear exudate of pH 2.6 was boiled, then cooled, and its pH determined. It had not been changed and no color developed.

A sample of the exudate from *P. dryadeus*, the pH of which was 2.6, was diluted with distilled water to raise its pH value to 3.0. This required 13 parts of the water to 1 of the exudate. Also samples of the exudate with pH values of 2.6 were evaporated to dryness and the loss restored with distilled water. After thoroughly mixing, the pH values were again determined and were found to be 2.8.

ACIDITY OF THE EXPRESSED JUICE

The tissues of the three species of fungi collected from their native habitat were taken to the laboratory where the juice was expressed and the acidity of each determined. Cheese cloth was

folded around each sample—which in turn was placed in a cylinder of a Carver press. Gentle pressure was applied at first and a sample of the expressed juice was taken. As the pressure was increased other samples of the juice were taken also. The acidity of each was determined. The results are given in the accompanying graph, from which it is clear that the pH of the juice that was taken first was considerably more acid than that of the juice which came



GRAPH 1. Acidity of the expressed juice from fungal tissue obtained by gradational pressures. When the desired pressure was reached a sample of the juice was taken and the excess removed, then pressure was applied and another sample taken. This procedure was continued throughout. 1. *Polyporus dryadeus*, 2. *P. sulphureus*, 3. *Fistulina hepatica*.

out when the pressure was greater. The exudate from *P. dryadeus* was pH 2.6. The juice that came out by pressing to 1,000 pounds gave a higher pH value, and that which came out at a pressure between 8,000 and 10,000 had a pH value of 4.43. Increases in pH values were obtained also in comparable samples from *P. sulphureus* and from *F. hepatica* when similarly examined.

ACCOMPANYING OBSERVATIONS

It was observed during this study that many vinegar flies (*Drosophila cellaris*) were on and around the growth of *P. dryadeus,* yet the only sign that the fleshy growth was invaded was an occasional frothing. No larvae were seen at any one of the five locations where the fungi were found. The pressed juices from other fleshy fungi that were nearby had pH values near 4.8 and were almost destroyed by the larvae. In three of the five locations slugs (*Limax* sp.) were active and consumed large portions of the fleshy growth.

DISCUSSION

Exuding of water by certain fungi found in their natural environment is comparable in several particulars with that which occurs in green plants. Certain outstanding differences, however, are evident. The fungi start exuding in the morning when the temperature is rising and quit near midday, whereas the exuding by vascular plants starts when the temperature of the air in the evening is falling and may continue into the morning of the next day. According to numerous workers root-pressure is responsible for this phenomenon by plants. Since fungi have no roots this phenomenon in fungi cannot be a result of root-pressure. Either the factor causing exudation by the two organisms is the same or there is a different factor for each organism. In vascular plants activities continue while the temperature of the air is falling. Translocation of sugars and root-elongation are at a high rate at this time. Exuding by fungi is accelerated by rising temperature and thus increased metabolic activity should parallel this increase. Because the metabolic activities are parallel in both types of organisms—one bearing roots, the other bearing none—the part that root-pressure performs in this phenomenon can be questioned. This leads to the suggestion that the exuding of water by certain autotrophic and heterotrophic organisms is correlated with high metabolic activity. The flow of water with its solutes being probably in one direction only is in accord with the conclusions of Buller (**1933**) that the flow of protoplasm in the mycelium of *Fimetaria* is in the direction toward rapidly growing hyphae without any reversal.

The inorganic elements that were present in the exudate from *P. dryadeus* duplicate in many instances those that were found in the exudate of *P. longipes* (Buller **1934**). Recorded in parts per million some of the elements were K 500, Mg 110, Ca 25, P. 1 but these represented only a small part of the total solids. The major portion apparently consisted of organic matter, although Buller (**1934**) says that none was found in the exudate of *P. longipes,* an allied species. This organic matter consisted of reducing substances as well as a transparent gelatinous residue, the composition of which was not studied. Apparently a part of this was cells of microscopic organisms for, like the exudate from green plants (Wilson **1923**), the exudate from *P. dryadeus* contained many bacteria. The positive tests for formaldehyde were unexpected. One reagent indicated that this compound was comparatively abundant, equalling about forty parts in a million. This seems large in comparison with traces that may be found in the atmosphere. The observation that vinegar flies do not breed in the fleshy growth where the pH values were 2.6 but did in certain other fungal growths where the pH value was higher indicates that other fleshy fungi in which these flies do not breed may be strongly acid also.

SUMMARY

The exudates from three species of fleshy fungi growing in their natural environment were collected and examined. The total solids varied from 1.7 to 2.72 per cent. The pH value of each was low, being for *Polyporus dryadeus* 2.6. The water contained bacteria, actinomyces, reducing substances, a material giving the formaldehyde reaction and certain inorganic constituents. About 500 p.p.m. of potassium and about 1 p.p.m. of phosphorus were present. The exudate was highly buffered and contained a gelatinous material that was not studied.

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VARIATION IN FRUIT BODIES OF CYATHUS STERCOREUS PRODUCED IN CULTURE

HAROLD J. BRODIE

(WITH 3 FIGURES)

Lloyd (2) and other students of the Nidulariaceae or Bird's Nest Fungi have frequently remarked upon the variability of certain species, of which the well known coprophilous *Cyathus stercoreus* (Schw.) De Toni provides a good example. While this species is constant in its principal diagnostic features, the fungus cups show great diversity in different collections as to size, shape and color. Lloyd regarded the whole assemblage of described varieties of this *Cyathus* as representing but one variable species, and he reduced to synonymy with *C. stercoreus* about half a dozen very similar fungi that had been described as distinct species.

That at least part of the variability of this fungus has apparently a genetic basis is indicated by the writer's studies (1) of pure cultures. Various haploid mycelia were combined to produce a series of diploid mycelia, and, upon some of the latter, fruit bodies developed. The differences between the fruit bodies arising on the various strains were so striking that it seemed worth while to present a brief report on the matter.

Studies of *C. stercoreus* in this laboratory have thus far shown that the fungus is heterothallic and tetrapolar. Haploid mycelia exhibit marked differences from one another in color, texture and growth rate. When compatible haploids are paired, the diploid mycelia resulting show corresponding differences; there is every indication that a number of characteristics such as color, texture and growth rate are inherited. Thus, when white haploids are paired, the resulting diploid is white; when brown haploids are paired, the diploid is deep brown; when white haploids are paired with brown haploids, light brown diploids of various intensities of color are produced.

MATERIALS AND METHODS

Details concerning the source and manipulation of cultures of *C. stercoreus* have already been published by the writer (1), a brief restatement of which is pertinent to the present report. From a single peridiole of a fruit body of *Cyathus stercoreus* that appeared spontaneously on an old culture of horse dung in this laboratory, 60 single basidiospore cultures were obtained. Under ordinary conditions the basidiospores do not germinate readily, but it was found that heating them at 40° C. in distilled water for 48 hrs. induced about 60 per cent germination. Monospore mycelia are haploid and grow readily on Kauffman's agar, to which yeast extract and a trace of ferrous sulphate are added. When haploid mycelia are paired, the mating reactions show a regular tetrapolar pattern. Diploid mycelia, as they were obtained, were transferred to stock tubes of agar for further study. When it appeared that this organism might afford opportunity for genetic studies, it became desirable to induce and control the production of spore-bearing fruit bodies in culture. It had been observed that rudimentary fruit bodies occasionally develop on diploid mycelia grown on a variety of ordinary nutrient agar media. A search was then made for a medium which would give good mycelial growth and would enable the fungi to fruit. Ten variants of a basic formula were tested and the following medium was adopted merely because it gave maximum growth: agar 20 gm.; maltose 5 gm.; dextrose 2 gm.; glycerine 2 gm.; peptone 0.2 gm.; potassium acid phosphate (monobasic) 0.5 gm.; yeast extract 0.2 gm.; ferrous sulphate, trace; distilled water to make one liter of medium. Detailed study of the nutritional requirements of *C. stercoreus* has not been made, and it cannot as yet be stated that this medium satisfies completely the requirements of *C. stercoreus*. The medium has served, however, for the continuous and vigorous growth of over three hundred monosporous and diploid mycelia for over a year.

On this agar, a considerable number of diploid mycelia produce fruit bodies, which are generally small and abortive. By the addition of cellulose in the form of strips of filter paper, the medium was rendered capable of supporting the development of numerous fruit bodies, which were normal in their ability to produce viable

FIG. 1. Fruit bodies of *Cyathus stercoreus*.

basidiospores. Fruit bodies were also produced in abundance when diploid mycelia were transferred to jars of sterilized horse dung. On dung, the production of the fungus cups was more prolific but the fruit bodies did not differ appreciably from those produced on the agar medium. The fruit bodies shown in figures 1 and 2 were all obtained from diploid mycelia growing on aliquots of the agar medium. Although slight differences were observed between specimens produced in succession on any one culture, these differences were in no respect comparable to the differences between specimens arising from different cultures. Reference to figure 3 will make clear the genealogy of each of the cultures and fruit bodies described below. A series of haploid mycelia was obtained from a single peridiole of a single wild-type fruit body. These haploids were paired in all possible combinations and from those combinations which were fertile, diploid mycelia were obtained. Certain of the diploid mycelia produced fruit bodies in culture and these are described herewith.

No fruit bodies or even rudiments of them developed on any of the haploid mycelia even when these were transferred to the above mentioned medium.

FIG. 1. Fruit bodies of *Cyathus stercoreus*.

TYPES OF FRUIT BODIES

Figures 1 and 2 show the mature fruit bodies that grew on seven different diploid mycelia of *C. stercoreus*. Each specimen (or group of specimens) is a representative sample of a series of fruit bodies. It will be seen that the various types show marked differences in size, shape and color. In some instances, the specimens are so unlike the fruit body from which the haploid cultures were obtained originally (wild type), that one would scarcely believe that they belong to the same species.

To facilitate comparison and reduce description, two tables are given showing the characteristics of the parent mycelia and of the fruit bodies. Table 1 sets out the appearance of the haploid parent mycelia and of diploid mycelia developed from them when the haploids were paired. These diploid mycelia produced the fruit bodies illustrated in the photographs. In Table 2, the characteristics of the fruit bodies are compared. A few comments about the different types may now be made.

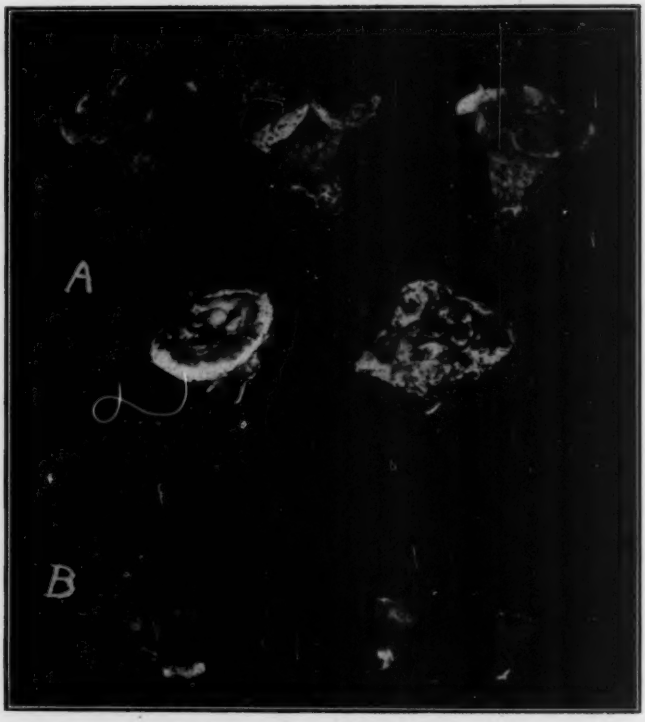

FIG. 2. Fruit bodies of *Cyathus stercoreus*.

1. *Color*.[1] The original wild type specimen from which all the cultures were derived and over two hundred fruit bodies produced by a diploid mycelium (No. N3.MM) obtained by culturing tissue taken from the base of the original specimen were all Cinnamon Brown according to Ridgway (**4**). Fruit bodies of the same color have also been obtained from a large number of the diploid progeny now in culture. These are not listed in Table 2 and will not be specially dealt with here.

[1] Kodachrome transparencies have been made of mycelia and fruit bodies to provide a permanent record of color differences. Some idea of the differences in color between the various fruit bodies illustrated in figure 1 can be obtained from the photograph, since all the specimens were photographed together.

TABLE 1

CHARACTERISTICS OF SOME HAPLOID MYCELIA OF *Cyathus stercoreus* AND OF THE DIPLOID MYCELIA FROM WHICH FRUIT BODIES WERE OBTAINED

Haploid				×	Haploid				→	Diploid		
No.	Sex Genotype	Color (Ridgway)	Texture		No.	Sex Genotype	Color (Ridgway)	Texture		No.	Color (Ridgway)	Texture
										N3.MM*	Cinnamon to Sayal brown	Fluffy
53	*aB*	Pale ochraceous buff	Fluffy		29	*Ab*	Pale cinnamon	Fluffy		53.29	Pinkish buff	Velvety
53	*aB*	Pale ochraceous buff	Fluffy		2	*Ab*	Cartridge buff	Fluffy		53.2	Pale cartridge buff	Fluffy
41B	*ab*	Mummy brown	Velvety		28S	*AB*	Pinkish cinnamon	Fluffy		41B.28S	Sayal brown	Fluffy
33	*aB*	Pure white	Plaster-like		29	*Ab*	White to pinkish cinnamon	Fluffy		33.29	White to very pale cinnamon	Fluffy
33	*aB*	Pure white	Plaster-like		6	*Ab*	Ivory	Fluffy		33.6	Cartridge buff	Velvety
13	*ab*	Ivory	Fluffy		40	*AB*	Pale ochraceous	Fluffy		13.40	Pale clay color	Fluffy
33	*aB*	Pure white	Plaster-like		18	*Ab*	Ivory to cartridge buff	Fluffy		33.18	Cartridge buff	Velvety

* N3.MM, tissue culture from original parent specimen.

TABLE 2

COMPARISON OF FRUIT BODIES DEVELOPED ON DIPLOID MYCELIA OF *Cyathus stercoreus*

Culture Number	Color of Cup (Ridgway)	Shape	Angle of Sides	Height, mm.	Diameter at Mouth, mm.	Dimensions of Peridioles, mm.	Spore Size in Microns	Outstanding Characteristics
N3.MM (FIG. 1*B*)	Cinnamon brown to Dresden brown; basal mycelial emplacement amber brown	Conical; mouth flaring slightly	75°	15–20	8–10	2 × 2.5	18–32 × 25–35	Cinnamon brown color, regular conical form, conspicuous brown basal mycelial emplacement.
53.29 (FIG. 2*A*)	Wood brown to buffy brown	Very broad funnel-shaped with strongly flaring sulcate mouth	60–70°	7–10	8–12	2 × 2.5	32–35 × 35–37	Grey brown color, extremely short cup with widely flaring mouth, peridioles not as black as in wild type.
53.2 (FIG. 2*B*)	Army brown to Natal brown	Regular conical, not flaring, minute	70°	4–6	3–4	1.5 × 1.75	32–35 × 32–38	Dark purplish brown, minute cups, small peridioles.
41B.28S (FIG. 1*C*)	Brussels brown with base amber brown	Conical, not flaring, malformed	80°	7–9	4–5	2 × 2.5	28–32 × 32–35	Deep brown color and irregular shape
33.29 (FIG. 1*A*)	Cartridge buff to cream buff with conspicuous russet base	Slender, flaring only at mouth	85°	15–20	6–8	1.75 × 2	22–25 × 32–40	Light grey brown with reddish base, slender form.
33.6 (FIG. 1*D*)	Cinnamon buff with cap ferruginous when young	Conical, not flaring at mouth	80°	10–12	5–6	1.75 × 2	28–32 × 32–36	Light buff color with reddish cap.
13.40 (FIG. 3)	Drab, with Brussels brown base	Broad conical	70°	10–12	8–10	1.75 × 2	25–35 × 32–35	Greyish brown, broad conical form and brown base.
33.18 (FIG. 1*E*)	Drab, without brown base	Broad conical	65°	10–12	7–10	1.5 × 1.75	25–35 × 32–36	Greyish brown, broad conical form, no brown at base, small peridioles

Some cultures produced fruit bodies darker in color than the wild type. For example, the cups developed on culture No. 41B. 28S (FIG. 1*C*) are Army Brown to Natal Brown, that is, considerably deeper in shade than the wild type.

Among the most remarkable of the series are those of light color, all of which developed on light colored diploid mycelia. The palest fruit bodies obtained to date grew from culture No. 33.29 (FIG. 1*A*). If one did not know beforehand that these fungi had been obtained by pairing certain haploids of *C. stercoreus,* one would be puzzled as to their species identity. It is interesting to note that Lloyd (**2**, p. 20) mentions specimens from India "of so light a color that I did not recognize them at first."

Variation in color is not confined to the cup as a whole. Certain parts of the fruit body may be specially colored in some cultures. All cups developed on culture No. 33.29 have a bright reddish brown base which shows (FIG. 1*A*) as dark shading at the base of each cup. Another interesting type is 33.6 in which the cup when young has a bright rust colored cap (FIG. 1*D*).

2. *Shape.* The original wild type specimen, and those produced by the tissue culture (N3.MM) from that specimen (FIG. 1*B*), were rather more elongate than are many wild specimens, especially those that grow on dung. The cups from several cultures are considerably more slender than the wild type, and have an attenuated base, as in culture No. 33.29 (FIG. 1*A*). Such slender stalked forms were referred by Tulasne (**5**) to the form *Lesueurii.* A broader type of cup was developed on several cultures, exemplified by No. 33.18 (FIG. 1*E*).

The most extreme deviation from the shape of the wild-type fruit body occurs in culture No. 53.29 (FIG. 2*A*). These extraordinary cups are broad and flat, some specimens being almost saucer-shaped.

The mouth of the fruit body of *C. stercoreus* is ordinarily not or only slightly flared. This condition is shown by the fruit bodies produced on culture No. 33.18 (FIG. 1*E*). However, extreme flaring develops in cups of culture No. 53.29 (FIG. 2*A*). In the latter specimens the cup is also strongly sulcate or furrowed, a character not at all typical of *C. stercoreus* but suggesting the flaring sulcate mouth of *C. vernicosus* (Bull.) DC.

33.18 (FIG. 1*E*)	Drab, without brown base	Broad conical	65°	10–12	7–10	1.5 × 1.75	25–35 × 32–36	Greyish brown, broad conical form, no brown at base, small peridioles

3. *Size.* The majority of specimens developed in laboratory culture have been about as large as wild type specimens. As yet none has been obtained that is larger than the wild type.

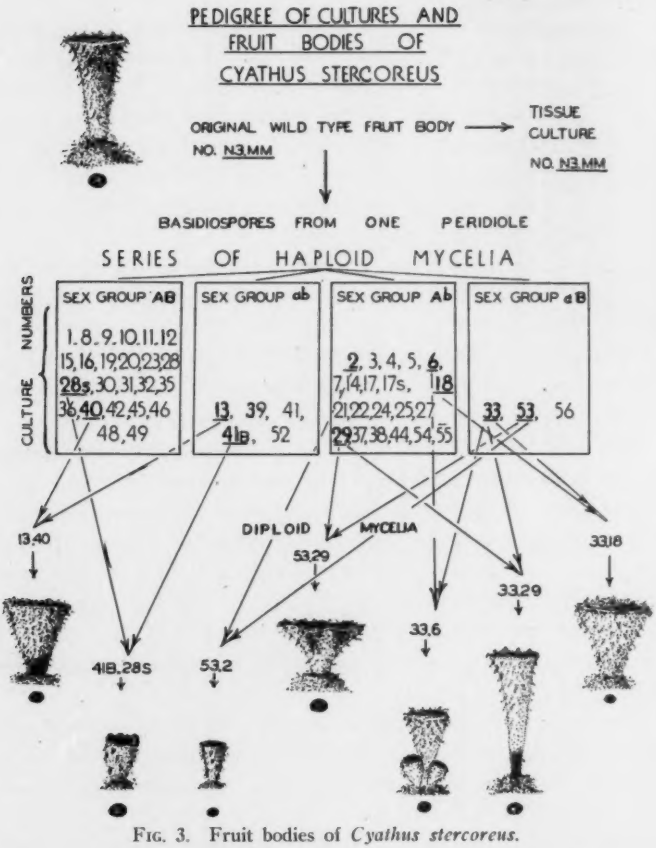

FIG. 3. Fruit bodies of *Cyathus stercoreus.*

One mycelium has produced minute cups. Specimens obtained from culture No. 53.2 (FIG. 2*B*) are dwarf and range from one fourth to one fifth the height of the wild type plant. Tulasne (5) referred small forms to the variety *minor,* concerning which Lloyd (2) remarks "there is no such thing as separating the various collections."

4. *Peridioles.* The peridioles in most cultures do not differ greatly in size from those of the wild type. Small peridioles, however, are characteristic of every specimen from cultures No. 53.2 and 33.18 (see TABLE 2 and FIG. 3).

Peridioles of *C. stercoreus* are typically black. One exception only has been noted in the cultures: the peridioles from cups of culture No. 53.29 are grey brown.

5. *Size of Basidiospores.* In the Nidulariaceae, basidiospores undergo enlargement after being dislodged from their basidia, a matter which was investigated by Martin (3). One therefore finds considerable variation in size among the spores of any one peridiole.

No conspicuous difference in size of the spores of the different strains was noted when fifty spores were measured for each culture. In some strains, the range in spore size is slightly greater than in others; but, in general, the mature spores are fairly uniform from strain to strain (TABLE 2). It is interesting to note that although the peridioles of 33.6 and of 13.40 are much smaller than normal, the spores within them are of average size.

GENERAL CONSIDERATIONS

That several distinct types of fruit bodies of *Cyathus stercoreus* can be produced in laboratory culture on diploid mycelia obtained from haploids, all originally derived from the spores of a single peridiole of one wild-type fruit body and then combined in various ways, is demonstrated by the foregoing account. Analysis of the genetic nature of these various types has not been completed, so that it is not known to what extent any self propagating lines may have been established.

One of the first questions that arises concerns the ability of the fruit bodies developed in pure culture to maintain themselves in nature. As yet we have no experimental evidence on this point, but it seems reasonable to infer that some of the forms of *C. stercoreus* described above, or other similar forms, exist in nature. Lloyd (2) and others who have studied these fungi have noted that the following types of fruit bodies may be collected in nature:

1. Short, unstalked forms usually growing on manure. These are considered by Lloyd as representing the type form of *C. stercoreus.*
2. Tall, slender forms with stalked cups. Lloyd assigns these to the form *Lesueurii.*
3. Small forms which Tulasne (**5**) called "var. *minor.*"
4. Stalked slender forms with strong development of mycelium at the base of the plant forming a conspicuous brown ball. Lloyd refers these to the form *rufipes* and correctly points out that, as most species of *Cyathus* commonly develop a basal mycelial ball, this character is of doubtful value for species differentiation.
5. Extremely pale specimens such as those mentioned by Lloyd as coming from India.

Specimens that seem representative of all the groups listed above may be found among the different types described in this paper. In addition, the cultures have produced three types that do not appear to have been mentioned by collectors, *viz.:* 53.29 with its wide sulcate cups; 33.29 with its very pale cups, red brown at the base; and 33.6 with its cups provided with a reddish cap when young.

The stand taken by Lloyd seems justified, *viz.,* that *Cyathus stercoreus* is a variable species and that it is impracticable to separate from it as distinct forms (in some cases species) those specimens that are different in the shape of the cups, size of the cups and in some minor respects. On the other hand, practically all the specimens produced by the writer's cultures have the cup covered with shaggy hairs, have black peridioles devoid of tunica, and spores that are subglobose and between 30 and 40 μ in diameter. It would appear that these latter characters are therefore more reliable or less variable for the purpose of species definition in *C. stercoreus* than are the shape and size of the cups.

Relatively few of the basidiomycetous fungi that have been studied in pure culture have produced fruit bodies in culture. As a result, we have too little knowledge of the extent to which the differences between specimens of any one "species" collected in nature may represent variability inherent in the fungus and of the

extent to which the differences may be made the basis of a legitimate species concept. It is with this problem in mind that the present study of *C. stercoreus* is brought to the attention of mycologists.

SUMMARY

1. The coprophilous Bird's Nest Fungus *Cyathus stercoreus* has been induced to fruit in laboratory culture.

2. From a long series of haploid mycelia, all derived from spores of a single peridiole of one wild type specimen, a large number of diploid strains have been obtained that differ from one another in color, texture, growth rate and other characters according to the nature of the haploids from which they were produced.

3. Different strains of diploid mycelium fruiting in culture have produced fruit bodies of several different types, some so unlike the parental wild type as to bear little superficial resemblance to *C. stercoreus*.

4. The most distinctive types of fruit bodies illustrated and described are: a small deep brown abortive form; a tall slender, very pale form with a reddish brown base; a broad, flat, saucer-shaped form with sulcate cup; a minute or dwarf form; and a greyish form provided with a bright rust colored cap when young.

5. The characters of the species that have appeared least variable in culture are the hairy nature of the cup, the color of the peridioles and their lack of a tunica or outer covering, and the average size of mature basidiospores.

6. The possible connection between these culture types of fruit bodies and the various forms of *C. stercoreus* that have been described from nature is discussed.

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DESCRIPTIONS OF ILLUSTRATIONS

FIG. 1. Various types of fruit bodies of *Cyathus stercoreus* produced in culture: *B*, No. N3.MM (specimens developed on tissue culture from base of original wild type plant and identical with original parent specimen); *A*, *C*, *D*, *E*, various types produced on different diploid mycelia obtained by combining certain haploids, all themselves derived from spores of the single original parent specimen; *A*, No. 33.29; *C*, No. 41B.28S; *D*, No. 33.6; *E*, No. 33.18. × 2.

FIG. 2. Two other types of fruit bodies of *Cyathus stercoreus* from same series as those shown in figure 1: *A*, No. 53.29; *B*, No. 53.2. × 2.

FIG. 3. Diagram showing the origin of various types of fruit bodies of *Cyathus stercoreus* described and illustrated in this paper. From a single wild-type fruit body (No. N3.MM), many haploid mycelia were obtained. Pairings of certain of the haploids produced the diploid mycelia Nos. 13.40, 41B.28S, 53.2, 53.29, 33.6, 33.29 and 33.18. Each of these diploid mycelia gave rise to a distinct type of fruit body different from the original wild-type fruit body. Fruit bodies and the peridioles developed within them are represented natural size.

EMENDATIONS TO OUR PROPOSALS CONCERNING THE NOMENCLATURE OF THE GILL FUNGI

ROLF SINGER AND ALEXANDER H. SMITH

Since our proposals first appeared (Mycologia **38**: 240–299. 1946), we have continued to check and recheck on the correctness of our data and the practical desirability of our proposals. This work has been helped by discussions with Dr. M. A. Donk who spent several months at the Farlow Herbarium, working on Basidiomycetes and comparing notes with the senior author on various aspects of nomenclature and systematics.

In spite of the fact that only five items have turned out to be, in one way or another, in need of emendation or correction, we believe that a speedy publication of the changes in the proposals is desirable even though they might be of no immediate nomenclatural importance or seem to be minor technicalities. They will, however, emend the set of facts on which we base our proposals, and will be of interest to those who, two years from now, must decide whether or not they will approve the proposals concerning the nomenclature of the gill fungi as outlined in our paper.

On p. 258, between XII and XIII, W. G. Smith's work, Clavis Agaricinorum, 1870, was omitted. In this, the genus *Lepista* (Fr.) W. G. Smith, l.c. p. 26, was first considered as a genus after it had been treated as a section of *Paxillus* by Fries in Epicrisis p. 315, 1838. The only possible, logical and practical type species, occurring both in Fries' and in Smith's definition of this taxonomic unit, is *Paxillus lepista* Fr. If this species, as we now propose, is considered as the *species typica* of *Lepista,* it turns out that *Rhodopaxillus* R. Maire becomes a synonym of *Lepista,* which has a solid priority. This is, of course, important only for those authors who separate this group from *Tricholoma* and *Clitocybe.* Aside from that, it makes our previous discussions on *Lepista* (see no. 73, p. 266, l.c. and no. 81, p. 269, l.c.) unnecessary. These should be considered as deleted.

On the same page (258), between XII and the above insertion,

we must insert the genus *Inocybe* (Fr.) Fr. which was given generic status by Fries himself in Monographia Hymenomycetum Sueciae **2**: 346. 1863; not by Quélet ten years later as it may appear from our account (no. 72, p. 266, l.c.). Since Fries made this change in his comments on *Agaricus trechisporus* Berk., and since he expressly included rough spores as a character of the genus, it is necessary to propose a rough spored *Inocybe* as lectotype. Consequently we now propose *Agaricus trechisporus* Berkeley, Outl. Brit. Fungol. p. 156, 1869, as lectotype. Under these circumstances *Clypeus* and *Astrosporina* become synonyms of *Inocybe* and there is no valid generic name for the smooth spored species if they were to be considered generically distinct.

On p. 280, the type species of the genus *Geopetalum* Pat. is indicated as *G. petaloides*. We would now consider this choice as unfortunate since it has turned out that another one of the original species of this genus, *G. carbonarium* (A. & S.) Pat. (*Cantharellus carbonarius* A. & S. ex Fr.), is not congeneric with the *petaloides* group (whose legal generic name is *Hohenbuehelia*) and would remain without a generic name unless *Geopetalum* were revived in this sense. We therefore propose to replace *G. petaloides* (Bull. ex Fr.) Pat. by *Cantharellus carbonarius* A. & S. ex Fr. as the type species of the genus *Geopetalum*.

On p. 295 we proposed to consider the genus *Rhodophyllus* Quél. as nomen conservandum if used for a generic unit larger than the genus *Entoloma* (Fr.) Quél. Some mycologists seem to be opposed to this proposal because they believe it is out of line with the type concept. We believe it can be defended, but it now appears that the point is no longer applicable to the present case since the senior author (Singer, 1948, in press) has been able to prove the correctness of Burt's suggestion (1922) that the genus *Acurtis* Fries (1849) is the carpophoroid stage of *Rhodophyllus abortivus*. Fries placed the genus in the Clavariaceae. Thus the name *Acurtis* has definite priority over all the other names which might possibly be applied to *Rhodophyllus*. Those who insist on maintaining the artificial series of genera *Entoloma, Leptonia, Nolanea, Eccilia, Claudopus* and *Clitopilus* (not sensu R. Maire) would have to apply the name *Acurtis* to the species with decurrent gills and fleshy stipes which intergrade with some species of *Entoloma* whereas in the case of conservation of *Rhodophyllus,*

this latter genus would replace *Entoloma*. Those who now consider that all these genera are properly placed under one generic name would use *Acurtis* if they adhered to the rules. In either case the failure to conserve *Rhodophyllus* would introduce a name never used for any recognized group of gill fungi, and would make wholesale new combinations necessary. Our proposal to conserve the generic name *Rhodophyllus* Quél. conditionally is therefore herewith withdrawn, and we hereby propose, unconditionally, *Rhodophyllus* Quél. for conservation against *Acurtis* Fr., *Entoloma* (Fr.) Quél., *Leptonia* (Fr.) Quél., *Nolanea* (Fr.) Quél., *Eccilia* (Fr.) Quél., and *Claudopus* (Fr.) Gillet.

There is one possible source of disagreement which we wish to point out. Some might regard Article 65 of the Rules as applying in this case and discard *Acurtis* on that basis. The question is, is the carpophoroid stage of *Rhodophyllus abortivus* a monstrosity in the sense of the meaning of the Article or not? In our estimation Article 65 does not apply because this carpophoroid stage has been adequately demonstrated to be a characteristic (*i.e.*, normal) part of this organism. We do not deny that it is possible to disagree with this point of view on the basis of a different interpretation of the term "monstrosity." But this alternative interpretation would necessarily lead the argument to a discussion of the physiology of the organism involved. Since no experimental work has been done in this direction, the question would then be left open. Under these circumstances, the application of the name *Acurtis* is at least a threat to the continuity of nomenclature and, as such, should be eliminated by conserving *Rhodophyllus*.

On p. 290, the following two genera should be added: XXXV. **Ex R. Kühner & R. Maire, Etude de la réaction de la membrane sporique à l'iode, Bull. Soc. Myc. Fr. 50 (1): 9–24. 1934.**

199. ASPROPAXILLUS Kühn. & Mre., *l.c.* p. 13. *A. giganteus* (Fr.) Kühn. & Mre.

Status of generic name. Valid, but considered synonymous with *Clitocybe*, or *Paxillus* by some authors, by others considered synonymous with *Leucopaxillus*.

200. XEROMPHALINA Kühn. & Mre., *l.c.* p. 18. *X. campanella* (Batsch ex Fr.) Kühn. & Mre.

Status of generic name. Valid, accepted by many modern authors.

THE SWINGLE SPHACELOMA HAND LENS AND EARLY RECORDS OF THE PATHOGENE OF CITRUS SCAB [1]

ANNA E. JENKINS *

(WITH 1 FIGURE)

Fawcett (1, p. 2) has written that "the first extensive scientific investigations of Citrus diseases in the United States from the standpoint of cause and control were begun [in Florida] by W. T. Swingle and H. J. Webber in 1892." In the division of the work, as Dr. Swingle has told me, one of the citrus diseases he investigated was "scab or verrucosis."

An essential part of Swingle's technique in gaging the effectiveness of his experimental spraying for the control of scab was the use of a hand lens of unusually high magnification (× 40). This had been made in New York according to his specifications. In publishing the results of this early experimental work he (6, p. 21–24) did not refer to his dependence upon this practical field tool. Quite by accident and only of late I learned of its existence. By Dr. Swingle's courtesy I was able to obtain a photograph of it for permanent record (FIG. 1, *C*). Early in my study of the scab pathogene I had the benefit of Swingle's manuscript drawings of the fungus as he examined it under the compound microscope. Certain of these are here published with his permission (FIG. 1, *D*). An ample specimen of scab on sour-orange leaves that Swingle col-

[1] This paper was published by title in the program of the Mycological Society of America, 11th Annual Meeting, Cleveland, Ohio, September 12–14, 1944. Since I could not attend, I found it opportune to discuss the subject at the Society's St. Louis meeting (March 27–31, 1946). This was in connection with my presentation relative to the Jenkins-Bitancourt Myriangiales selecti exsiccati, Fascicles 2–6 (4), of which fascicle 3 contains significant material of citrus scab (sour orange scab). In order that it may be available other than by the published title, the report, essentially in abstract, is published here.

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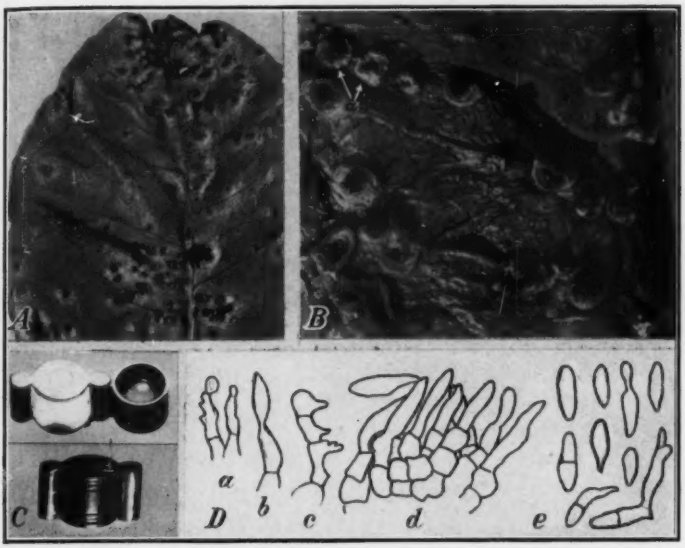

FIG. 1. *A* and *B*. Citrus scab on sour orange leaves showing the dusky conidial growth of the pathogene on their surfaces. (Part of *B* was published elsewhere (3, fig. 2, *C*) to show the light colored growth of a secondary *Fusarium* (*a*). Specimen from Gainesville, Florida, 1928. *A*, ×1; *B*, ×6½. *B*. Two views of the hand lens. ×1. *C*. Swingle's manuscript drawings of the fungus showing individual conidiophores (*a*, *b*, *c*), clump of conidiophores arising from stromatic development beneath (*d*), and a group of detached conidia (*e*).

lected in Florida on April 12, 1892, appears as number 107 in the Jenkins-Bitancourt Myriangiales selecti exsiccati (4).

Swingle's early drawings and specimen of the fungus, as well as knowledge of the existence of the Swingle *Sphaceloma* hand lens, are essential to a satisfactory reconstruction of the taxonomic history of the organism. That eminent scientist's work with citrus scab belongs, of course, to the latter part of the "epoch-making period from 1885 to 1895" so termed by Galloway (2) in his graphic account of "Progress in the treatment of plant diseases in the United States." Dr. Swingle's continued researches in citrology have recently culminated in his "Botany of citrus and its wild relatives of the orange subfamily" (5).

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NOTES AND BRIEF ARTICLES

On ZYGODESMUS: *Zygodesmus* is one of that considerable number of genera that are, or ought to be, tagged with the condemnatory phrase "in the sense of Saccardo but not of the author." As Corda described it (Icones Fung. **1**: 11. 1837) the genus was chiefly characterized by "flocci . . . geniculato-contracti, et dein per ramos vel geniculos transversaliter exsertis, conjugatis." The clamp-connections thus described (perhaps for the first time) and illustrated (Pl. 2, fig. 164, 165) gave the genus its name (Ζῠγόω, join, + Δέσμα, link). The spores, "simplices, . . . pellucidae," were scarcely determinative. The two species originally assigned to the genus, *Z. Hypochnoides* and *Z. ochraceus*, are more likely to have been species of *Corticium* than anything else; but since the spore-bearing organs are not described, the species might possibly have been clamp-bearing Moniliaceae like those reported by Linder (Lloydia **5**: 165-207. 1942) in *Oidium*. In either case, there is insufficient published detail to permit even the tentative identification of any known fungi with Corda's descriptions, and the type specimens are missing from Corda's herbarium in Prague (Pilát, Mus. Nat. Prague Acta **1B**: 139–170. 1938). Both specific names are therefore *nomina dubia*, to be rejected under Art. 63 of the Rules. Since one or the other of these species must be the type of the genus, *Zygodesmus* is likewise a *nomen dubium*. We know only that it was published for fungi floccose, clamp-bearing, and hyaline-spored.

Three years after the publication of his genus Corda added to it a third species, *Z. fuscus* (Icones Fung. **4**: 26. Pl. 6, fig. 81. 1840). This fungus had little in common with the earlier species, or with the generic description, beyond the bare possession of hyphae and spores. The hyphae were fuscous and without clamps, and the spores were spiny and fuscous. Just as the earlier species, if imperfect, as described, should be Moniliaceae, so *Z. fuscus* should belong to the Dematiaceae. It is this alien species which Saccardo, disregarding the clear implications of the generic name,

the generic description, and the original species, seems to have adopted as the typical one (Syll. Fung. 4: 283–288. 1886). At any rate, this is the one which he chose for the first place and most careful treatment in his group (? subgenus) *Euzygodesmus;* the original species are listed towards the end of a third group. Other authors have followed this lead, and Clements & Shear (Gen. Fung. 395. 1931) have formally designated *Z. fuscus* as the type of the genus.

Through the kindness of Dr. A. Pilát of the National Museum, Prague, the type specimen of *Z. fuscus* was borrowed for study. As could have been predicted, it proved to be a *Tomentella, T. biennis* (Fr.) A. M. Rogers.[1] The specimen is poor, lacking the discolorous hymenium and subhymenium so well described by Bourdot & Galzin (Hym. France 486 [1928]), and retaining only the fuscous-brown subicular hyphae and the spores; but from their apiculi the spores must be basidiospores, and the fungus not only can be traced in Bourdot's key but agrees in all respects with more perfect material of *T. biennis.*

Zygodesmus then presents one more case where "general usage . . . instead of priority of publication" (Clements & Shear, Gen. Fung. 15. 1931), if adopted as the basis for designation of types, would make a bad situation considerably worse. Not only is *Z. fuscus* not eligible for inclusion in the genus as described by Corda, but its adoption as type would necessitate that the name *Zygodesmus* Corda 1837 should supersede *Tomentella* Pat. 1887. As here shown, however, that is not only unnecessary but impossible.

What then are the fungi which authors since Corda have assigned to *Zygodesmus?* A dozen or more belong in *Tomentella;* at least five are members of *Pellicularia;* others belong to *Peniophora* and *Coniophora.* The genus is a mine of interesting resupinate Basidiomycetes. Since Linder has found that three species belong to *Oidium,* it is still possible that fungi will be discovered in *Zygodesmus* sensu auctt. which can properly be included within the Dematiaceae. But neither *Zygodesmus* Corda

[1] *Thelephora biennis* Fr., Syst. Mycol. 1: 449. 1821; *Tomentella phylacteris* [Bull.] Bourd. & Galz. apud Bourd. & Maire, Soc. Mycol. France Bul. 36: 81. 1920; **Tomentella biennis** (Fr.) A. M. Rogers comb. nov.

nor *Zygodesmus* sensu Saccardo belongs there.—DONALD P. ROGERS, NEW YORK BOTANICAL GARDEN.

RUSSULA TRICOLOR Murr.

Russula tricolor Murr. Lloydia **8**: 272. 1945

Dr. Rolf Singer informs me that Roger Heim used this name before I did, so I propose **Russula patriotica** comb. nov. for my species.—W. A. MURRILL

PROPOSALS FOR THE AMENDMENT OF ART. 64 OF THE INTERNATIONAL RULES OF BOTANICAL NOMENCLATURE

Art. 64. A name of a taxonomic group must be rejected if the characters of that group were derived from two or more entirely discordant elements, especially if those elements were erroneously supposed to form part of the same individual. A list of names to be abandoned for this reason (*nomina confusa*) will form Appendix V.

Examples: The characters of the genus *Schrebera* L. (*Sp. Pl.* ed. 2, 1662: 1763, *Gen. Pl.* ed. 6, 124: 1764), were derived from the two genera *Cuscuta* and *Myrica* (parasite and host) (see Retz. *Obs.* VI, 15: 1791). The characters of the genus *Actinotinus* Oliv. (in Hook. *Ic. Pl. t.* 1740: 1888) were derived from the two genera *Viburnum* and *Aesculus*, owing to the inflorescence of a *Viburnum* having been inserted into the terminal bud of an *Aesculus* by a native Chinese collector. The names *Schrebera* and *Actinotinus* must therefore be abandoned.

Proposal 1: for "especially" substitute "and."

Argument: Although the wording of the Rule indicates that it may be applied to names of groups whose characters were derived from discordant elements *not* supposed to form part of the same individual, its only useful application is to names based on discordant elements *supposed* to form part of the same individual; and its application to names of the former sort must result in the discarding of very large numbers of well established names, and must constitute an invitation to extensive abuse.

The Rule first appeared as a proposal published without elaboration or explanation in the form: "Every one should refuse to admit

a name . . . when the group which it designates embraces elements altogether incoherent . . ." (Burnat, E., & Durand, T. Propositions de changements aux lois de la nomenclature botanique de 1867, p. 11 (Art. 53). 1903), and became Art. 51 (4) of the 1905 Rules. Such a phrasing being evidently ambiguous, an expanded statement was proposed by certain British botanists (International Botanical Congress, Cambridge (England), 1930. Nomenclature proposals by British botanists, p. 28 (Art. 69). 1929) and was incorporated unaltered into the Rules by action of the Cambridge congress. There is no record of interpretative discussion at either congress. It is, however, significant that although the British committee pointed out (*l.c.*, p. 43) that the generic name *Crinodendron* had been rejected by Sprague (under an earlier Rule) because it had "been shown to be based on a mixture of at least two species belonging to different *families*," and nevertheless was subsequently retained by Schneider, no attempt was made to support the opinion of Sprague by listing the case of *Crinodendron* among the Examples. On the contrary, these relate exclusively (*l.c.*, p. 28) to cases where the "discordant . . . elements were erroneously supposed to form part of the same individual." This creates a strong presumption that it is only to such cases that the Rule ought to be applied.

Actually, there is no need for any broader application of the Rule. Its text was written, just as the case of *Crinodendron* was judged, before the type concept had become a part of the Rules. The principle that is now applicable, and now generally applied, is that when two or more "incoherent" or "discordant" specimens form the basis for a specific name, or two or more "incoherent" or "discordant" elements (such as species) form the basis for a name of a higher rank, the name is "permanently attached" to "that constituent element of a group" (Art. 18) which was designated, or is selected, as the type. With the type concept forming a part of the Rules, there is then only one class of cases where a Rule like Art. 64 is needed—the cases where the type itself consists of "discordant elements"—*i.e.*, where those "elements were erroneously supposed to form part of the same individual." Such cases are not infrequent among fungi, where careful microscopic examination may be needed to disentangle the mixed individuals, and, as shown by

the Examples earlier referred to, they occur occasionally among vascular plants.

The literal application of the Rule as it stands would mean that every specific name published with a description drawn up from representatives of two species (or two subspecific categories), every genus drawn up for members of different genera, and so on, should by its operation be discarded. Since the species and genera of older botanists are often held by more recent ones to embrace two or more of such "elements" (*Agaricus* Fries, for example, including species now often assigned to different families, *Clavaria* Fries, *Hydnum* Fries, and *Thelephora* Fr. members of different subclasses, and *Peziza* Fr. members of different classes), the needless mortality among names could be very extensive. The remedy is to limit the Rule to its needed application before someone becomes too conscientious—in the manner of O. Kuntze.

Proposal 2: after "individual" insert the sentence, "Names given to *Lichenes* are considered to apply to the fungal component only."

Argument: Art. 64 as it stands invalidates most names given to lichens—all that antedate the Schwendenerian hypothesis. Commonly the algal component has a name proper to it; the fungal component rarely or perhaps never has. In the majority of lichens the fungus is the more conspicuous element, and supplies the majority of the characters used in taxonomy; unless new names are to be given to these fungi, the ones already applied to lichens should not be invalidated.—DONALD P. ROGERS, NEW YORK BOTANICAL GARDEN.